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ENGINEERING

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POWER OVER NATURE

THE time has long since passed when science could be practised solely for its value as a rewarding intellectual pursuit. It is still that to scientists who esteem the cardinal tradition of their calling, but it now impinges so forcibly on the lives of men and women generally that the scientist must come out of his laboratory and listen to the world's comments on his work. There is no group more worthy of his attention than those men of sensibility and imagination – the playwrights, essayists, critics, even poets – who aspire to see beyond the present and to discern the path their contemporaries are treading. For such writers have sometimes been a generation in advance of their day in their power to recognise impending change. What, then, are they saying to-day?

Mr. Charles Morgan, who, as much as any other living writer, has faced up to the social implications of science, has lately suggested there is reason to hope that there may be a halt for many centuries in all but the minor developments of technology. "History," he says, "moves in phases; the power-phase may be drawing to its close." The development of man's power over Nature has reached a stage where it implies a subversion of the natural order. Our "power-predicament" is that we have no means of collectively rejecting a distortion of our lives which intuitively we dread. "We are addicts." No sensitive mind, he argues, can be unaware of a stirring of dread in the world – not only of fear that science is condemning civilisation to bodily death, but of spiritual dread that life is being deprived of its order and proportion.

Mr. Morgan has communicated his thoughts in his latest play, *The Burning Glass;* and he has stated his beliefs and hopes in a preface to the play – a preface "On Power over Nature." It is illuminating to compare this phrase with the form of words used by Tredgold in his historic definition of the profession of a civil engineer: "the art of directing the great sources of power in Nature for the use and convenience of man." (For the present purpose we may reasonably ignore the fact that an engineer and a scientist are usually, though not always, separate and distinct.) It is not difficult to admire the grandeur of Tredgold's definition, with its strong sense of service to mankind, its awe of Nature. And his use of the word "art" when he might have said "science" – even if we allow for the wide Nineteenth Century conception of the arts (industrial as well as fine) – is perhaps a reminder that the engineer uses his imagination and experience as well as his formulæ. Mr. Morgan's phrase is different. He has written it only five generations after Tredgold's definition, but such have been the advances of science and engineering that he can speak of man's "power over Nature."

The Burning Glass is a play about the dilemma of a scientist who finds, in the course of his disinterested researches into the artificial control of the weather, that he can focus the power of the sun in such a way as to increase its intensity per unit area, and to such a degree that a city could be burnt to the ground or a lake could be boiled away. No one need trouble to argue whether or not such a technique is scientifically practicable, now or in the future; the subject of the play is Christopher Terriford's dilemma. At first, horrified by the military potentialities of his discovery, he desperately wanted to destroy all memory of it. The weather control machine could not be kept secret, but the unique setting of its controls which gave it this unprecedented power was one among countless possible settings. He chanced on the setting by one of those occasional intuitive and inexplicable leaps of the mind which creative workers experience. So long, therefore, as he could keep it secret he could retain control of the machine's full power.

At a later stage he was tempted by the hope of precluding its military use and allowing its "peaceful" uses, but this course was clearly impracticable, or at least it could not be sustained indefinitely. In the end he chose the opposite policy: he forbade all uses except, in certain circumstances, the military.

That may seem to have been a strange decision to reach; it was, indeed, a compromise for reasons of state, the nature of which the play alone should be allowed to explain. As a matter of principle it is second in importance to the fundamental issue: whether Terriford was right in rejecting the "old high tradition of scientific research, which he had been brought up to love and honour" – a tradition which presupposed a community of knowledge to which scientists freely contributed their results. Mr. Morgan, in his preface, is concerned with the profound spiritual reasons for Terriford's view. The columns of ENGINEERING are not a proper place for commenting on those spiritual reasons – every man should examine them for himself – but the suggestion of "a halt for many centuries in all but the minor developments of technology" is a challenging thought to implant in the minds of scientists and engineers. It is hardly defensible for other than spiritual reasons.

Weekly Survey

LAST YEAR, THIS YEAR . . .

Looking back on the series of Engineering Outlook articles which is concluded in this issue, a few main issues seem to dominate all others, and on their solution, perhaps, depends the prosperity of the British metal and metal-using industries during the next few years. The following are the main features of developments in 1953.

First, a general fall in the order books of most manufacturers of machinery and plant. The Engineering and Allied Employers National Federation pointed out that the volume of orders booked during the year ended May, 1953, was 25 per cent. less than in the previous year. The fall in the subsequent twelve months is likely to be at least as great. This could mean little more than a clearing of the decks. Undoubtedly, most companies now have a better chance to quote attractive delivery dates in those world markets which are becoming more and more competitive.

There was a general fall in deliveries of metals and engineering goods for export from £110·1 millions a month in 1952, to £108·6 millions in 1953. If the rise in prices is taken into account, this must mean a substantial fall in volume. Where industries have expanded their output, such as the motor industry has done, the expansion has been due very largely to higher home sales.

An unduly large proportion of the output of metal and metal-using industries was sold on the home market. Consumer expenditure on durable goods was heavy, particularly during the last quarter of 1953. Home sales of washing machines, radio sets, refrigerators and cars more than made up for the fall in the exports of these products. Possible increases in wage rates and the freer use of hire purchase may accentuate this trend. A heavy demand for plant and materials from nationalised industries has also contributed to the high consumption of metal goods at home. Coal, steel, electricity, gas, railways, and building and contracting went ahead with expansion programmes which have been held up for many years by shortages of materials.

There was a substantial fall, with very few exceptions, in commodity prices, which have only recently become stabilised at a low level. This fall has led to a considerable improvement in the British terms of trade, but it has seriously affected export demand for British engineering products, particularly in the Commonwealth, and has made potential buyers much more price-conscious than hitherto. There was a disappointing level of capital investment in the private section of manufacturing industry, taking it as a whole. Mechanical handling equipment was an exception, though the demand for works trucks and conveyors also tended to decline towards the end of the year. When British engineering companies were unable to quote competitive export prices it must, at least in part, have been due to their use of obsolete machinery and plant.

There has been a considerable growth in competition in export markets, particularly from Germany and Japan. For example, the German shipbuilding industry is now second to the United Kingdom, which again led the world in 1953, and the Volkswagen cars, recently reduced in price by 7 per cent., are selling very successfully against British small cars, particularly on the Continent. This growth of competition is likely to place increasing emphasis on price levels, and to demand greater energy in marketing and more resourcefulness in design.

The possibility of some British engineering companies being unable to export their manufacturing surplus (a situation which has not yet arisen, but order books suggest that it might during the current year) is likely to lead to greater pressure, especially from Germany and Japan, to develop trade with the Soviet block and China. Happily, recent events have shown that British manufacturers are well able to obtain their share.

The amounts spent on research and development of new products appear to have been inadequate. It is essential that British products should not lag behind their American or German equivalents in design, and it is even more important that British engineering should lead the world with new products. This is probably the most important lesson to be learnt from trading during the past year. It can be done, as some sections of the industry have shown.

Efforts to sell products overseas have often proved ineffective. Some products have been marketed without sufficient study and preparation, and sales forces have been neglected. British engineering companies, with notable exceptions, have not been adequately represented and have tended to sell from London without much knowledge of their markets. This is probably the most urgent problem facing the industry.

Perhaps the principal need of British industry is re-equipment with up-to-date machinery. Only that way can substantial savings be made in production costs. It is hoped, therefore, as pointed out in the last article in the series, that the Chancellor of the Exchequer will provide an incentive, such as allowing manufacturers to write-off plant as quickly as they wish.

* * *

THE D.S.I.R.

The Department of Scientific and Industrial Research (which controls the work of the National Physical Laboratory, the Mechanical Engineering Research Organisation and other Government research stations, in addition to the support they give to the research associations of this country) are now able to plan their arrangements for expansion which have been delayed by the economic situation since the war. Unless some unforeseen difficulty arises, it is expected that the post-war plans will be completed by 1959. The Government have provided, also, that a shortfall of expenditure in any year may, subject to the necessary funds being voted by Parliament, be made good in subsequent years. In the Report for the year 1952–53 of the D.S.I.R. (H.M. Stationery Office, price 8*s*.), the Advisory Council remark that "we are greatly relieved to see this clear road before us."

The Mechanical Engineering Research Organisation has, perhaps, suffered most from the lack of means. The Council deplore the delay that has occurred in building the new laboratory at East Kilbride and in staffing the establishment. Progress has been much slower than the objectives warranted, since less than a third of the laboratory has been built and less than a half of the staff recruited, in spite of the fact that the D.S.I.R. have devoted 40 per cent. of their post-war building allocation and 20 per cent. of their post-war staff increase to the purpose. However, a staff of over 250 has been built up on the foundation of less than one-fifth of that number transferred from the National Physical Laboratory as its nucleus. By 1959, the staff will number between 500 and 700.

The number of research associations aided by D.S.I.R. grants grew from 21 in 1939, to 41 in 1952. The 41 associations had, in 1952, a total income of £4,000,000, of which £1,300,000 was from the grants. The Council state, however, that there is still need for a substantial expansion of many of the existing associations and, *prima facie*, for the creation of a number of new ones. Approval has been given for a grant not exceeding £100,000 to be made to the British Electrical and Allied Industries Research Association towards heavy capital expenditure. A similar grant has been approved to assist the British Coke Research Association in building a full-scale test-oven plant.

* * *

A LEAD DEVELOPMENT ASSOCIATION

Under the sponsorship of the leading Commonwealth producers of lead, the Lead Development Association has been formed as a non-profit earning body. The objects of the Association are to extend knowledge regarding the manifold uses of lead and to foster applications of the metal.

Hitherto, the only organisation of its kind in this country, giving information on the metal and on matters connected with its uses, has been the Lead Industries Development Council, which, however, confined its activities to those connected with lead sheet and lead pipe. With the formation of the new Association, the name Lead Industries Development Council will cease and its activities will continue as the Lead Sheet and Pipe Council, which becomes an associate member of the Lead Development Association.

The offices of the new Lead Development Association, and also of the Lead Sheet and Pipe Council, are at Eagle House, Jermyn-street, London, S.W.1.

* * *

ATOMIC ENERGY SIMPLIFIED

Sir Christopher Hinton, now a Fellow of the Royal Society (as reported on page 389), followed his recent James Clayton Lecture to the Institution of Mechanical Engineers by an address on "Atomic Energy Made Easy," to the graduate and student sections of the Institutions of Civil, Mechanical, and Electrical Engineers. In a civilisation such as ours, he said, dependent as it was on the liberation of heat from material sources, the application of nuclear fission to the production of explosives was of merely incidental significance compared with its application to power production.

He drew a distinction between the physical and the chemical properties of atoms. A physical reaction between two atoms (for example, between atoms of heavy hydrogen to form helium), yielded several million times as much energy as a chemical reaction between the same atoms. The problem was to discover a means of excitation to set the reaction going. He dealt with the relationship between uranium 235, which is fissile and found only in small quantities, and uranium 238, which is stable and comparatively abundant, and he described how they would be used together in a thermally controlled reactor to form fissionable plutonium and provide heat energy.

The time will come when the engineering aspects of atomic power production will be as widely understood among engineers as are the engineering aspects of conventional methods of power production. Sir Christopher Hinton's lectures will help to spread such understanding.

Letters to the Editor

A SQUAT LOAD-MEASURING GAUGE

Pressure under Railway Tracks

SIR, The article on "A Squat Load-Measuring Gauge" by Mr. C. W. Newberry, which appeared in your issue of March 12 on page 339, will be of interest to those desirous of measuring small compressive forces, even though in Fig. 5 the gauge is shown on the ram of a jack which appears to be of about 30 tons capacity!

Gauges of this type are useful for measuring earth pressures, and it was for this purpose that, in 1945, the British Railways (then the L.M.S. Railway) Research Department at Derby conceived and constructed load tables to show their ability to record loads accurately even though eccentric. In May, 1946, a few of the load tables were buried in earth under a load-imposing rig; since then others have been buried under railway track for periods of over two years, and very satisfactory recordings made of the pressures due to trains passing at speeds up to 81 m.p.h.

Yours faithfully,
J. C. LOACH,
Development Officer,
Vehicle and Track Testing.
British Railways Research Department,
Derby.
March 17, 1954.

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PRIZES FOR SHIPWRIGHT APPRENTICES

The Court of Assistants of the Worshipful Company of Shipwrights announce that they will award in 1954, as in previous years, a number of prizes to shipyard apprentices; and that Her Majesty the Queen, who is Patron of the Company, has again been graciously pleased to award a Silver Medal to the prize-winning apprentice who holds the first prize for three years. H.R.H. the Duke of Edinburgh is the Prime Warden of the Company for 1954.

The competition is open to shipwright and plater apprentices in all private shipbuilding and repairing establishments in England, Wales, Scotland and Northern Ireland. Boatbuilding apprentices in such yards are also eligible. A booklet giving details of the prizes and the conditions of entry may be obtained from the Honorary Clerk to the Company, 24 St. Mary Axe, London, E.C.3. Firms wishing to enter candidates should apply for the necessary forms to the Honorary Clerk; and the forms, when completed, should be sent to the chairman of the appropriate local committee not later than the end of April. The final examination will be held in London on Friday, June 25, 1954.

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ROLLS-ROYCE APPRENTICE TRAINING

A new edition of a brochure giving full particulars of the various apprentice training schemes they have in operation has been prepared by Rolls-Royce Limited, Derby. Four of the six forms of apprenticeship available are designed to produce skilled craftsmen, draughtsmen or technicians, professional engineers and research or laboratory workers. Another course is provided for boys who intend to graduate in engineering at a residential university after completing their National Service, and provision is also made for boys interested in the commercial side of the engineering industry. We described the company's apprentice training school in our issue for July 25, 1952, on page 107. Copies of the brochure can be obtained from the Training Manager, Rolls-Royce Limited, Derby.

CITY AND GUILDS OF LONDON INSTITUTE

First Insignia Awards in Technology

It may be recalled that some twelve months ago the Council of the City and Guilds of London Institute established the Insignia Award in Technology to provide a high qualification for persons in industry whose initial training was based primarily on practical experience combined with theoretical study, and who, having gained appropriate City and Guilds Certificates as craftsmen or technicians, have now advanced in their industry by a combination of progressive experience and further study.

A candidate upon whom the Award is conferred receives a warrant specifying thereon the section of industry and the branch of technology in which his knowledge and skill are recognised, and, under the Institute's Royal Charter, he is authorised to use the letters C.G.I.A.

Briefly, the regulations governing Insignia awards state that a candidate must be at least 30 years of age and be sponsored by three referees of appropriate standing. He must have been apprenticed or otherwise suitably trained in his industry, must hold relevant full Technological Certificates of the Institute, and have had a minimum of seven years of progressive experience in his industry. (It has been decided, however, that, for an interim period, candidates may be considered even though they hold no full Technological Certificate of the City and Guilds Institute, provided they are in possession of others deemed to be acceptable by the executive award committee.) Finally, the candidate is required to write a thesis of between 10,000 and 20,000 words on a technological topic associated with his work.

The first list of successful candidates has now been issued. It contains the names of three men upon whom the Insignia Award has been conferred. The first is Mr. A. A. Daultrey, a production engineer, whose thesis was entitled "The Layout and Practical Application of a Machine Shop engaged in the Production of Jigs and Dies, with special Reference to Pressed-Steel Automobile Bodies." The second, Mr. Edward Ryalls, has received the distinction for his contributions to welding technology and in respect of a thesis on "Oxy-Acetylene Welding and Allied Processes in the Engineering Industry." The third is Mr. Tom Hurst, a foundry technologist whose thesis dealt with "Re-design to Ensure Sound Castings and Reduce Cost of Manufacture." In addition, some seven more candidates from other fields of industry have been reported upon favourably, both by their assessors and by the appropriate interviewing panels, and these are awaiting confirmation of award by the executive committee.

In accordance with a rule permitting one annual award to suitable recipients of distinction in respect of each of the five main industrial groups, the Council of the Institute has conferred the Insignia Award upon Dr. H. W. Clarke (chemical industries – metallurgy), managing director of James Booth and Company, Limited, Birmingham, and prominent in the non-ferrous metal industries for many years; Mr. John Batty, A.R.I.B.A. (constructional industries – architecture), a distinguished architect; Mr. E. H. Jolley, M.I.E.E. (electrical industries – telecommunications), staff engineer, Post Office; Mr. S. H. Russell (mechanical industries – foundry engineering), a past President of the Institute of British Foundrymen; and Mr. T. R. Barrow, A.T.I. (textile industries – hosiery), works superintendent, Meridian Limited.

LIVING STANDARDS AND TECHNICAL TRAINING

Colombo Plan Students

Under the Colombo Plan, formulated at Colombo in January, 1950, with the object of raising living standards in the countries of south and south-east Asia by means of international co-operative effort, almost 500 men and women have so far been sent to study administrative, welfare and technical subjects in the United Kingdom. The students present at a recent reception represented not only the countries which took part in the inauguration of the Plan but also certain countries which have since become associated with it. Among the guests were trainees from Ceylon, India, Pakistan, Burma, Nepal, the Philippines and Thailand, and the subjects which they have come to this country to study include aeronautical engineering, concrete technology, marine engineering, aerial survey, fuel technology and hydro-electric engineering.

Training is provided not only by universities and technical colleges but also by private companies and Government departments, and the duration of courses ranges from six months to three years. Expert assistance has been received from such bodies as the British Iron and Steel Federation and the Ministry of Labour and from individual specialists such as Professor E. H. Thompson, of University College, London, who planned the aerial survey course, and Professor A. L. L. Baker, of Imperial College, who arranged hydro-electric and concrete technology courses.

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PERKINS DIESEL ENGINES TO BE MADE IN FRANCE

The firm of F. Perkins, Limited, Peterborough, makers of Diesel engines for agricultural and transport purposes, began to export their engines to France soon after the recent war, and to-day, in spite of the difficulties of international exchange, there are some 6,500 Perkins engines of various types in use in that country. To cope with the growing demand, it has now been decided to manufacture the engines in France, and on March 19, at a reception in Peterborough which was attended by a large number of members of the French Parliamentary Agricultural Committee, of French agricultural societies, and of the French national and agricultural Press, Mr. Frank Perkins, the chairman and managing director of the company, explained the arrangements that have been made.

A wholly-owned French subsidiary company, F. Perkins S.A., was formed in May, 1952, to handle the necessary negotiations and, as a result, through the agency of M. Jean Delcroix, chairman of that company, arrangements have been made with the Ateliers G.S.P., who have factories in Paris, Courbevoie, Chateaudun and Albert, to undertake the manufacture of the engines.

Initially, the Ateliers G.S.P. will assemble the Perkins "P" series of engines at Courbevoie from British-made parts. They will then gradually introduce French-made parts until eventually the engines will be wholly of French manufacture. The French and British parts will be completely interchangeable. Mr. Perkins mentioned, in his address, that the British company had imported a quantity of French forgings and cylinder-block castings in the past, for use in engines made at Peterborough, and had been well pleased with their quality. Neither the parent company in Peterborough nor their French associated company will own any shares in the Ateliers G.S.P., which will remain under independent French management. While the production in France under the new arrangement is expected to be only about 3,500 engines during the first twelve months, Mr. Perkins considered that, thereafter, the output should increase rapidly. The engines will be used at first mainly for agricultural purposes, in tractors, combine harvesters, etc., but a much wider eventual use is envisaged, comparable in variety to that in the British market.

CLOCK AND INSTRUMENT TECHNOLOGY

Facilities of the National College

To provide an opportunity for the instrument industries to inspect the educational facilities available at the National College of Horology and Instrument Technology, Northampton Polytechnic, London, E.C.1, the authorities of the College organised an open day, in collaboration with the Scientific Instrument Manufacturers' Association, on Tuesday, March 16, at which the workshops and laboratories were on view.

The National College of Horology, it may be recalled, was set up in 1947 by the Ministry of Education to provide training and research facilities for the industry specialising in the manufacture of clocks, watches and other high-precision mechanisms. At present the College provides a basic three-year diploma course of theoretical training and workshop practice for young men of 16 and over holding suitable educational qualifications.

Some of the students are sponsored by firms to whom they are apprenticed, but many boys enter the college straight from school under the five-year apprenticeship scheme of the British Clock and Watch Manufacturers' Association. After they have completed their diploma course they receive two years' works training at one of the member firms. Since many of the students enter the instrument industry rather than the clock-making industry, the Scientific Instrument Manufacturers' Association have under consideration a similar apprenticeship scheme.

The National College of Horology is exceptionally well equipped with machinery such as is currently used in the horological and precision engineering industries, so that students completing the course are thoroughly familiar with the type of equipment that they will be encountering when they join a manufacturing firm.

The demonstrations included first-year students working on their standard exercise, the construction of an 8-day fusee-driven clock, and second- and third-year students working on deck-watch movements. Other students demonstrated the use of some of the automatic machines and were seen making tools for use in them. Some of the special instruments that the College make for outside organisations were also on view. Among the research equipment with which the College is equipped is a Shortt free pendulum clock and a quartz crystal clock constructed in the college from data provided by the Post Office Research Department, identical with the crystal clocks used for the transmission of the B.B.C. time signals; this clock has a mean error rate of less than 0·02 second per day.

It is hoped to arouse wide interest among the instrument manufacturers in post-graduate courses in instrument technology, covering a wide range of subjects, which are to be established in October, 1954, and which will make full use of the facilities available in the Polytechnic as well as those available in the National College itself. In addition to basic courses in physics, instrument design and technology, metrology and industrial administration, it is proposed that post-graduate students should have the option of choosing from subjects such as advanced mathematics, metallurgy, instrument workshop practice, or instrument theory covering the mechanical, electrical, electronic, optical, industrial control or servomechanism fields. These courses, it is hoped, will attract ex-Service students.

At the Open Day, therefore, the Department of Instrument Engineering of the Northampton Polytechnic also displayed their laboratory and workshops.

WORK STUDY TRAINING COURSES

MOTION STUDY AND FINANCIAL INCENTIVES

The Work Study School established by the West of England Employers' Association at Brunel House in Bristol is unique, since no other employers' association sponsors regular courses in work study. As a result, the direct cost to members for the training provided is said to be about half that charged by firms of industrial consultants.

The principal instructor in the school is Mr. G. P. Wade, B.Sc., A.M.I.E.E., a former senior lecturer in work study in the Birmingham College of Technology. His assistant, Mr. G. R. Burn, A.M.I.Mech.E., was formerly chief motion and time study engineer in the High Wycombe factory of Messrs. Hoover, Limited.

During the past decade, the slogan of " higher productivity " has been used repeatedly to stress the necessity of obtaining a higher rate of production from our available resources of manpower, plant, and materials. Work study is a means of achieving higher productivity. The two methods employed are firstly to cut down the amount of work to be done, by reducing wasted time and effort, and secondly, to raise the level of physical and mental effort of all in industry by correctly applied financial incentives.

By the application of motion study, improved methods of production can be devised. Each job presents its own problem which must be solved as such, but a systematic approach to method improvement can be taught. Experience both in engineering and in other industries has proved that large savings in time and money can be attained by a properly-trained man, without expensive alterations to tools and equipment.

EQUITABLE WAGES

For fair working of financial incentive schemes which reward extra effort, the schemes must be based on accurate measurement of the amount of work performed by the individual or the group concerned. Modern techniques of time study, including effort rating, together with reasonable fatigue allowances, provide the best means of determining how long a job should take. The hourly rate for each trade has been decided by arbitration between employers and unions and, in the engineering industry, a complex wages structure has resulted. A systematic evaluation of the responsibilities, qualities and skills required by different jobs – job evaluation – enables a more equitable wages structure to be devised.

Established just over a year ago, the Work Study department at Brunel House has already run five courses for engineers holding responsible positions within their firms. These have been eight-week courses, the first four weeks of which are spent in instruction and practical work in Brunel House itself. For the next fortnight the students return to their own factories and apply the new techniques of work study—especially to current problems or projects, one of which the student takes back with him to study, under instruction, during the final two weeks.

ATTITUDE OF MANAGEMENT

The main emphasis of the course is on training engineers to a level at which they can make reliable time studies. A large number of rating sessions are carried out both to improve the engineers' ability to rate consistently with his own standard, and to ensure that his standard is in agreement with recognised standards of performance. As far as possible, the staff of the school follow the progress of their past students by visiting them whenever a suitable opportunity occurs.

The use made of the engineer's new knowledge by his firm depends mainly on the attitude of the management. In some firms, quick results have been achieved and marked progress is being made. The best results are being obtained where the management is keenly aware of the value of work study, and is prepared to make the necessary alterations in the organisation to enable the work study engineer to function effectively. A two-day appreciation course for higher management has been designed to explain the techniques and advantages of work study with the intention of creating the right atmosphere for successful applications of the methods.

Foremen also must understand the broad principles of work study and appreciate how it affects them if they are to co-operate wholeheartedly in applying it. Without their active support much of the value of work study will be lost. The department therefore gives a special five-day course designed especially for foremen.

The eight-week courses, however, represent the main work of the department, and in the five courses run so far, 50 men have been trained, each course being restricted to 10 men so that adequate practical instruction can be given to all. A feature of the courses is that, at the conclusion, an Open Day is arranged and students prepare demonstrations of the improved methods which they have developed on the projects brought from their firms. The management of each firm represented on the course is invited to attend, and to bring foremen or shop stewards who are likely to be interested. The members of each course are recalled for a day during the last week of the following course, thus providing for further interchange of ideas. So far, there has been a 100 per cent. attendance at these refresher courses – a measure of the popularity of the course.

REDUCING LABOUR COSTS

On the fifth Open Day, the projects displayed were mostly assembly operations of one kind or another, and it is in this type of work that simple motion study is best illustrated. As an example, an increase in production of 50 per cent. was obtained on the sub-assembly of an aircraft fuel valve by using a correctly designed holding fixture and a special spanner for holding a nut and washer. The study of one part of the assembly of an industrial moving-coil revolution counter has led to an estimated increase in production of 30 per cent. This study made use of storage trays as pallets moving with the work from the previous operation.

The Work Study School of the Engineering and Allied Employers' West of England Association is by no means the only work study school in Great Britain. One of the more recent of such schools to be established is at the College of Aeronautics at Cranfield, but, unlike the Bristol School, the Cranfield school is open to all. Full-time training in work study has much to recommend it, especially by allowing the engineer to study and master the principles and practice of work study without the distractions of his day-to-day duties. The staff of the Bristol school is shortly to be increased to three, and it is then intended to take 15 students to each course, so providing the West Country with still more fully-trained work study engineers.

THE INSTITUTE OF MARINE ENGINEERS

The fifty-first annual dinner of the Institute of Marine Engineers was held at Grosvenor House, Park-lane, London, W.1, on March 12, with Sir Gilmour Jenkins, K.C.B., K.B.E., M.C., Permanent Secretary to the Ministry of Transport and Civil Aviation, and President of the Institute, in the chair. About 1,200 members and guests were present.

His Excellency, Dr. D. U. Stikker, G.B.E., the Netherlands Ambassador, proposed the toast of the Royal and Merchant Navies of the British Commonwealth, and Vice-Admiral (E) F. T. Mason, C.B., Engineer-in-Chief to the Fleet, replied.

The Rt. Hon. A. T. Lennox-Boyd, M.P., Minister of Transport and Civil Aviation, proposed the toast of the Institute, and referred to the presence of His Excellency M. Per Preben Prebensen, G.C.V.O., C.B.E., the Norwegian Ambassador, and to the work of the Royal Norwegian Navy during the second World War. In replying, Sir Gilmour Jenkins referred to the work of the Institute and mentioned that it had acquired 914 new members during the past year.

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THE INSTITUTE OF REFRIGERATION

The anniversary dinner of the Institute of Refrigeration was held at the Savoy Hotel, London, on Wednesday, March 17, the President, Sir Charles G. Darwin, who had just returned from a visit to Thailand, occupying the chair. The attendance was 411.

Proposing the toast of "The Institute of Refrigeration," the Rt. Hon. Viscount Waverley, Chairman, Port of London Authority, said he doubted whether any engineering developments could be considered to have had a purely beneficial effect on society. Refrigeration, however, had not caused any harm.

The first refrigeration plant installed in the London docks was in 1892 and to-day there were 706,000 cub. ft. of cold-storage space. In the whole of London there was about 20,000,000 cub. ft. of cold storage space and the total volume in this country was 59,000,000 cub. ft.

In his reply, the President apologised to members for his absence abroad and explained that he had been engaged in the preparation of a report on the state of science in Thailand for UNESCO. He thought there were many opportunities for doing business with that country and one field in particular, where much could be done, was air conditioning. Turning to the progress of the Institute he said the Research Committee had now worked for a year and had acquainted itself fully with developments throughout the country. The National College for Heating, Ventilating, Refrigeration and Fan Engineering had not received the number of industry-sponsored entrants anticipated, and he urged those present to encourage the supply of students. Next year, 1955, the ninth International Congress of Refrigeration would be held in Paris, at the end of August.

The toast of "Science and Industry" was proposed by Sir Rupert de la Bere, who deplored the ever increasing growth of scientific power. Sir John D. Cockcroft, Director, Atomic Energy Research Establishment, Harwell, who replied, spoke of a visit to his establishment by an American who said our science was good but our technology weak.

The toast of "Our Guests" was proposed by Colonel H. Randal Steward, and Mr. E. G. Batt, Director, British Refrigeration Association, responded.

PERSONAL

MR. P. M. HOLLINGSWORTH, M.Eng. (L'pool), M.I.E.E., has been appointed chief engineer of the power cables division of British Insulated Callender's Cables Ltd., to succeed MR. W. P. FULLER on his eventual retirement. Mr. Hollingsworth will be stationed at 21 Bloomsbury-street, London, W.C.1.

DR. J. W. DRINKWATER, O.B.E., has been appointed Director of Engine Research and Development, Ministry of Supply, in succession to MR. R. H. WEIR, who has become Principal Director. Dr. Drinkwater has held the appointment of assistant director since 1948.

DR. B. G. NEAL, M.A., A.M.I.C.E., University lecturer in engineering at Cambridge, has been appointed Professor of Civil Engineering in the University College of Swansea (University of Wales), Singleton Park, Swansea.

COLONEL J. D. HAIGH, O.B.E., M.A., M.I.E.E., has been appointed Director of Electronics, Research and Development (Defence), Ministry of Supply, with effect from March 17. He has been promoted acting Brigadier on taking up his new post. MR. H. W. FORSHAW, O.B.E., M.Sc. Tech., M.I.E.E., has been appointed to succeed DR. G. W. SUTTON, as chief superintendent, Signals Research and Development Establishment, Christchurch, Hampshire. Dr. Sutton is leaving the public service on March 31.

MAJOR T. W. ADAM, managing director of the Monckton Coke and Chemical Co. Ltd., Barnsley, who has just retired after having been secretary of the Midland Institute of Mining Engineers for 34 years, is to be presented with the Peake Medal at a meeting of the Institute, to be held at Doncaster on April 1.

Mr. W. H. TAYLOR, B.Sc., A.M.I.E.E., recently appointed controller of education and personnel services to the General Electric Co. Ltd., Magnet House, Kingsway, London, W.C.2, has now taken up his new duties.

MR. G. M. L. LOGIE has retired from the position of manager of the Neptune Shipyard, Walker-on-Tyne, of Swan, Hunter, and Wigham Richardson Ltd. He joined the firm in 1904 as an apprentice draughtsman. His successor is MR. T. CHRISTIE.

MR. A. M. C. JENOUR, T.D., J.P., is to succeed MR. EUGENE BRUNNING, C.B.E., as chairman of board of Wales and Monmouthshire Industrial Estates Ltd., in June. Among new members of the board, appointed with effect from March 19, are MR. G. E. AERON-THOMAS, C.B.E., D.L., J.P., and MR. E. J. POWELL, M.I.C.E., M.I.Mun.E.

PROFESSOR C. R. SODERBERG, Fellow A.S.M.E., M.I.Mech.E., has been appointed dean of the School of Engineering, Massachusetts Institute of Technology, Cambridge, 39, Massachusetts, U.S.A., as from April 1.

MR. C. P. BIRKIN has succeeded the late MR. W. E. BENBOW as editor of our contemporary, *Iron and Steel* of the Louis Cassier Co. Ltd., one of the journals of Associated Iliffe Press Ltd., Dorset House, Stamford-street, London, S.E.1.

MR. A. G. PEACOCK, B.Sc., A.R.I.C., A.Inst.P., has resigned his position as secretary of the Scientific Instrument Manufacturers' Association and has joined the board of Mervyn Instruments, Copse-road, St. John's, Woking, Surrey.

Consequent upon the transfer of MR. C. P. STORR to the Dominions division of Metropolitan-Vickers Electrical Export Co. Ltd., MR. J. G. MILES, B.Sc. (Eng.), has been appointed the company's power systems engineer.

MR. E. H. NICHOLS has been appointed manager of the branch of W. T. Henley's Telegraph Works Co. Ltd., at Norwich, in succession to MR. J. NEWTON who has retired after 45 years of service with the company.

MR. G. T. NOBLE, hitherto manager for Scotland, has been made general sales manager to W. H. Heywood and Co., Ltd., Bayhall Works, Huddersfield. Mr. Noble's successor, MR. J. L. THOMAS, is now working from the firm's new Scottish address, 5 Newton-place, Glasgow, C.3. (Telephone: Glasgow Douglas 0103.)

MR. J. V. SPENLOVE BROWN, A.M.I.Mech.E., has left the factory planning department of Joseph Lucas Ltd., to become technical sales manager, Visual Planning Systems Ltd., Athlon-road, Manor Farm Estate, Alperton, Wembley.

MR. H. DUNN has been appointed sales manager, Scottish area for Wellworthy Ltd., Lymington, Hampshire. His office address remains 50 Wellington-street, Glasgow, C.2.

BUSINESS CHANGES

BIRLEC, LTD., Tyburn-road, Erdington, Birmingham 24, announce that their northern-area organisation has been removed from 63 Arundel-street, Sheffield, to new offices at 317 Glossop-road, Sheffield, 10. (Telephone: Sheffield 63258-9.)

THE BRITISH IRON AND STEEL FEDERATION, Steel House, Tothill-street, London, S.W.1, announce that owing to a change of policy it has been decided to cease publishing the journal, *Steel News*.

MESSRS. DEWRANCE & CO. LTD., announce that, on and after April 1, Flintshire, Denbighshire, Caernarvon and Anglesey will be included in the areas covered by their Manchester office at 32 Deansgate. The remainder of Wales will continue under the direction of their office at 6 Park-grove, Cardiff.

BROOK MOTORS LTD., Empress Works, Huddersfield, have removed their Newcastle-upon-Tyne sales office to larger premises at 35 Pink-lane. (Telephone: (unchanged) Newcastle 26763.) The company have also taken over recently another factory at Aspley, Huddersfield.

THE CRUCIBLE STEEL CO. OF AMERICA have acquired a 50 per cent. interest in the VACUUM METALS CORPORATION, formerly a wholly-owned subsidiary company of the National Research Corporation, 70 Memorial-drive, Cambridge, Massachusetts, U.S.A.

The address of the northern office of the ROCKWELL MACHINE TOOL CO. LTD., Welsh Harp, Edgware-road, London, N.W.2, is now 10 Canal-street, Waterloo-road, Stockport, Cheshire.

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THE ROYAL SOCIETY

Annual Election of Fellows

At a meeting held on March 18 the Royal Society elected into the Fellowship for 1954, among others, the persons mentioned below.

PROFESSOR T. MCF. CHERRY, Professor of Mathematics, University of Melbourne, and distinguished for his researches on transonic flow and for earlier work on orbits in celestial mechanics.

PROFESSOR E. G. COX, T.D., D.Sc., F.Inst.P., F.R.I.C., Professor of Inorganic and Physical Chemistry, University of Leeds, distinguished for his work on stereochemical problems in inorganic and organic chemistry by the application of X-ray crystallographic methods.

MR. F. C. FRANK, reader in Physics at the University of Bristol, who is distinguished for his original contributions to the theories of crystal growth, of plastic deformation, and of dislocations in crystalline solids.

SIR CHRISTOPHER HINTON, M.A., M.I.C.E., M.I.Mech.E., managing director, Industrial Group, Department of Atomic Energy. He is distinguished as an engineer who, by his leadership and by direct contributions, has played a major part in the development of large production plants in the Atomic Energy Project.

MR. J. L. PAWSEY, assistant-chief, Radiophysics Division, Commonwealth Scientific and Industrial Research Organisation, Sydney, Australia, who is distinguished for his contributions to techniques of radio and radar, and for his applications of these techniques to radio astronomy and to the study of the ionosphere.

MR. M. F. PERUTZ, lecturer in biophysics, University of Cambridge, who is distinguished among other matters for investigations of the structure, deformation and flow of glacier ice.

PROFESSOR A. J. S. PIPPARD, M.B.E., D.Sc., M.I.C.E., F.R.Ae.S., who holds the Chair of Civil Engineering at Imperial College of Science and Technology, London, and is distinguished for his theoretical and experimental contributions to the theory of structures.

PROFESSOR W. W. ROGOSINSKI, Professor of Pure Mathematics, University of Durham, and distinguished for his contributions to mathematical analysis, especially the Fourier series.

MR. H. G. THODE, head of Chemistry Department, McMaster University, Hamilton, Ontario, Canada, and distinguished for improvements in the technique of mass spectrometry.

MEASUREMENT OF TRAIN RESISTANCE

CRITICAL REVIEW OF BRITISH RAILWAYS' METHODS

It has been recognised, from a very early stage in the development of rail transport, that accurate information about the performance of locomotives and the running resistance of trains can contribute importantly to the reliable and economic operation of a railway system. The subject is obviously one for periodic re-investigation to take account of changes and improvements in motive power, rolling stock and track, and at the same time take advantage of developments in scientific knowledge, experimental equipment and testing techniques.

In this country, more so than abroad, the difficulties of accurate train testing under approximately service conditions have, until very recently, been aggravated by the absence of long, straight and level stretches of track in open country, on which steady states of train running can be achieved and maintained while experimental observations are made. To surmount the chief difficulty – that of automatically maintaining constant train speed irrespective of fluctuations in gradient, engine performance or train resistance – the London Midland and Scottish Railway constructed, between 1936 and 1939, a mobile testing plant which has been proved fully capable of all the functions for which it was intended. Dr. H. I. Andrews, then in the L.M.S. Railway Research Department, who was principally responsible for inventing and developing the plant, described it to the Institution of Mechanical Engineers in 1948, and it is sufficient here to recall that it comprises three electronically-controlled electrical braking cars used separately or in any combination along with a modern dynamometer and control car.

TEST RESULTS

From 1947 to 1951 the mobile testing plant has been used for a series of train resistance tests, the results of which were presented by Dr. Andrews in a paper to the Institution of Locomotive Engineers on February 10. The scope of the work included passenger and freight trains. One set of trials was conducted at speeds up to 70 m.p.h. on eight-coach trains of present standard passenger coaches, respectively in relatively "new" condition (10,000 miles after complete overhaul), and in "run-down" condition after having completed 150,000 miles since overhaul. Trials of freight vehicles were made with fitted, covered goods vans; variously-loaded open wagons, sheeted and unsheeted; and two patterns of goods brake vans – a 15-ton six-wheeler, and a 20-ton four-wheeled express goods brake. All these freight vehicles were of fairly modern design, equipped with oil-lubricated axleboxes and generally in average good condition. They were marshalled into trains of various lengths up to 50 vehicles and tested at speeds up to 50 m.p.h. Some of the earlier tests on passenger stock were made on the L.M.S. lines Rugby to Peterborough and Willesden to Rugby. The later and more extensive testing, subsequent to the nationalisation of the railways, was done on the more suitable Eastern Region routes between Peterborough and Grimsby and, in the case of freight trains, between March marshalling yard and Norwich.

During one series of trials between Willesden and Stafford on the London Midland Region main line, the mechanical resistance of a Class 5 4-6-0) steam locomotive, at speeds up to 70 m.p.h., was deduced from the difference between the mean value of tractive effort, obtained by indicating the cylinders, and the mean drawbar pull at the rear of the six-wheeled tender. A few tests were also made near Wath, up to a maximum speed of 50 m.p.h., on a standard Bo+Bo electric locomotive having pantograph collectors, resistance in this case being determined as the average difference between the electrically-measured tractive effort exerted by the motors through the gears, and drawbar pull.

For the resistance tests on locomotives, the dynamometer car was coupled to the locomotive by its force-measuring hook, the speed-controlling mobile testing cars being marshalled behind. For the tests on passenger coaches and goods trains, however, the speed-controlling cars were next to the locomotive, followed by the dynamometer car reversed end-for-end so that it recorded the tractive pull on the following train of vehicles. The tractive forces, so measured, were corrected for the effect of local track gradient on the known weight of the test train.

AIR RESISTANCE

More attention than in any previous train resistance trials in this country was paid to the determination of air resistance. A cup anemometer and a wind vane, mounted at about chimney height on a slender structure projecting well ahead of the locomotive front end, gave continuous graphical records in the dynamometer car of the speed and direction of the resultant wind relative to those of the train. On at least two occasions their readings were checked against those of instruments temporarily mounted alongside the line, while the temperature and barometric pressure of the atmosphere, from which air density could be derived, were regularly observed.

In contrast with these admirable experimental arrangements, the procedure adopted by Dr. Andrews for segregating atmospheric effects, so that air resistance coefficients can be presented for different types of vehicles under a reasonable range of natural wind conditions, and the total resistances of vehicles referred to some common condition (e.g., still air of standard density), is very indirect and unlikely to be readily understood by many members of the operating staffs whom the results are intended to serve, since it entails laborious statistical analysis of a converging Fourier cosine series. It leads, moreover, to the presence, in the formulated expressions for total train resistance, of a component proportional to the square of train speed additional to the component due to air resistance. Dr. Andrews offers no suggestion as to the origin of this, presumably mechanical, source of resistance which, in the case of goods vehicles, appears from the tabulated values to suffer remarkable variations with weight of vehicle and, in some circumstances, to become negative.

It may be noted, that the author's quoted values for ranges of atmospheric temperature and pressure correspond to possible extreme ranges of atmospheric density variation of 5 per cent. during the tests on coaches and 12 per cent. during those on goods trains. It would appear, therefore, that the density corrections, while usually smaller than these percentages, should have been applied since they are directly proportional to air resistance. In fact, however, they have been omitted as "negligibly small in comparison with the inevitable errors of observation." The wide scatter of points about curves depicting air resistance perhaps justifies such neglect, but it fails to explain the unlikely results that the air resistance of a Class 5 locomotive heading a train is only some 50 per cent. greater than that of one coach in the train, and substantially less than that of a 20-ton brake van at the end of a long freight train.

In view of such anomalous findings there is less than adequate justification for the remark, among the conclusions of the paper, that the measured air resistances are considerably lower than those forecast from wind tunnel experiments, owing to the difficulty of interpreting scale effects on models. Scale effect is, admittedly, in the direction to lower the air-resistance coefficients measured on small models in wind tunnels, but much of the disparity between the present results and those of comparable wind tunnel tests can be accounted for by the marked gradient which reduces natural wind speed near ground level, in conjunction with the experimental fact that the intrinsic air resistance of the undercarriage of a railway coach in an intermediate position along a train is less than that of the body.

PRACTICAL USE

Notwithstanding some reservations as regards accuracy, more particularly of air resistance, the results of these comprehensive trials will prove helpful in estimating the resistances of typical trains on British Railways. As a general rule the results are expressed in relation to train speed as coefficients in formulae of the common type: $R = A + BV + CV^2$ (which, incidentally, Dr. Andrews appears to attribute to the American investigator Edward C. Schmidt, although this type of train resistance formula was suggested in Britain by Scott-Russell* in 1846, and was scientifically analysed some 60 years later by Carus-Wilson†). Practical use of the results has been facilitated by curves of total specific resistance (lb. per ton of vehicle weight) plotted against train speed for each class of vehicle on the assumption of a natural wind speed of 10 m.p.h. from any direction, and by specimen calculations of the resistances of typical trains.

Among points of special interest is the observation that the present values of passenger coach resistance are lower than those measured by other investigators. The comparison between "reconditioned" and "run down" coaches shows little difference between the two conditions. Both resistances increase from about 3 lb. per ton at 10 m.p.h., where the run-down stock is slightly more resistant than the reconditioned, up to about 10 lb. per ton at 70 m.p.h., at which speed the reconditioned coaches have slightly the higher resistance. The resistance of open wagons is a little smaller than that of covered vans at low speeds, but greater at high speeds, the effects of sheeting open wagons, similarly loaded, being slight. The most interesting, if not unexpected, feature about the freight stock as a whole is the consistent reduction of resistance (lb. per ton) with increase of loading. This effect is also marked in the case of the 15-ton and 20-ton goods brakes, though the comparison here is doubtless also influenced by the fact that the lighter van has six wheels whereas the heavier has only four wheels and a somewhat longer wheelbase. For wagons and vans at speeds from 20 to 40 m.p.h. this reduction in specific resistance is approximately proportional to increase of total weight, with the striking consequence that, at the speeds usual with freight trains, the actual resistance (lb.) of wagons on straight level track is practically independent of

* *Proc. Inst. C.E.*, vol. 5, page 369 (1846).
† *Proc. Inst. C.E.*, vol. 171, page 227 (1908).

the load carried. The resistances of the Class 5 steam, and the Bo + Bo electric, locomotives are nearly alike, rising from about 13 lb. per ton at 10 m.p.h. to 17 or 18 lb. per ton at 50 m.p.h., that of the electric locomotive being the greater at the higher speed.

LIGHTING GENERATORS

A significant factor in passenger train working, to which the paper directs attention, is the resistance, additional to that measured in the road tests, due to the generation of electricity for train lighting and battery charging. Such resistance is highest at the "cutting-in" train speed of 17 m.p.h., and falls at a decreasing rate as speed increases. Dr. Andrews has computed train resistance values for a range of generator outputs and finds that, at 20 m.p.h., the resistance due to driving the generators of a passenger coach at ¾ output is 65 per cent. of the mechanical resistances, thus engrossing over one-third of the total tractive resistance. At 70 m.p.h. these proportions have fallen to about 6 per cent. and at lower generator outputs are negligible.

As regards the effects of curves and track condition on train resistance, the paper reports that no appreciable effects could be attributed to considerable differences in the subsoils on which various sections of the tracks covered by the tests were laid. It was usually impossible to measure any additional resistance due to sharp curvature because such curves were not long enough to accommodate the whole length of the test train. On the longer curves, of radius greater than 50 chains, any change of resistance was less than the normal variation along different lengths of track and consequently indeterminate.

If it may reasonably be inferred from this statement that the rolling resistance of trains is continuously fluctuating to extents which are themselves subject to secular change, the same may well be true of other sources of mechanical resistance, as it is certainly true of wind resistance. Such fluctuations, combined with errors of experimental measurement, contribute to the scatter of plotted observation points graphically recorded in the paper. It is clear that the mobile testing plant, while eliminating some sources of serious experimental error, has not made it possible for train resistance to be formulated with as much precision and certainty as could be desired. The results will, however, become increasingly valuable the more carefully and extensively they are correlated with the results of train operation under normal service conditions.

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COMPRESSED-AIR TOOLS

Films of Production and Use

Two colour films showing the production of air compressors and air-driven power tools at the works of Broom and Wade, Limited, High Wycombe, Buckinghamshire, and the application of these products in industry have been made.

The titles of the films, which are to be distributed throughout the world for display before chosen audiences, including technical colleges, are "Broomwade at Home" and "Broomwade at Work." They run for about half an hour each and the first gives a detailed survey of the company's works from the foundry to the dispatch department.

The second film deals with the use of compressed air. It showed air-operated small tools and hoists in use in factories. One ingenious machine shown was a plant for the production of glass ink bottles, in which air was used for forming. The bottles were moved from one forming operation to another by mechanically-operated fingers while still hot.

WHITWORTH SCHOLARSHIPS

Their Place and Purpose To-day

The 29th annual commemoration meeting of the Whitworth Society was held at Simpson's-in-the-Strand, London, on March 18, Professor S. J. Davies presiding over a company of some 60 members.

The proceedings at these dinners have for many years followed an established tradition. After the President has proposed the loyal toast and the silent toast to the memory of Sir Joseph Whitworth, a member proposes "Success to the Whitworth Society," and another proposes "The New Whitworth Scholars." The first of these toasts was proposed by Professor J. Diamond, who gave some interesting information about Joseph Whitworth's connection with the early days of Owens College. Professor Davies, who replied, suggested that Whitworth awards were not now altogether serving the purpose for which they were introduced, and a later speaker pointed out that so many scholarships and bursaries were now available that it was almost impossible for an able youth to avoid going to a university. Dr. Sopwith, who proposed the second toast, referred to the same matters. The general sense of the discussion was that Whitworth Scholarships should not be divorced from practical workshop experience.

It was announced that the Summer Meeting would be held in Portsmouth on June 29 and 30. The next President, Major-General A. R. Valon, will take office at that meeting.

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VERSATILE MOBILE CRANES

Shown in Action in Colour Film

Mobile cranes made by R. H. Neal and Company, Limited, Plant House, Ealing, London, W.5, were the subject of a film shown on March 10 at the Hammer Theatre, London. In his introduction to the film, Mr. Brian H. Neal, joint managing director of the company, said that the film had been made principally for distribution to overseas agents.

The film, which began with illustrations of economies effected by the use of mobile cranes, continued with a summary of their construction and included a close-up view of the submerged-arc automatic-welding process in operation. A completed crane was subjected to a 25 per cent. overload test; and, during a display of manœuvrability, another was steered in a tight circle while its jib was slewed simultaneously. The saving in time achieved by lowering the hook under power was also demonstrated in the film.

In the second part of the film, Neal cranes were shown in use on the premises of various concerns. "QM" and "NM" type cranes, fitted with cantilever, swan-necked and standard jibs and with hooks, electro-magnets, loading shovels and single-chain ring-discharge grabs, were seen in action equipped with pneumatic tyres or tracks. Other models presented were: the type "GM" crane, which, by means of a vertical telescopic mast, can lift loads of 15 cwt. to a height of 40 ft., and the type "R" 10-ton mobile crane.

The film, which is in colour, has a spoken commentary, and has been made by Gateway Film Productions Limited, 470 Green-lanes, London, N.13. Its running time is 30 minutes and copies of it are available for loan to other companies and organisations.

LAUNCHES AND TRIAL TRIPS

H.M.S. "HAZLETON."—Twin-screw coastal minesweeper, built by Cook, Welton and Gemmell, Ltd., Beverley, Yorkshire, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, February 6.

H.M.S. "KIRKLISTON."—Twin-screw coastal minesweeper, built by Harland and Wolff, Ltd., Belfast, for the Admiralty, London, S.W.1. Main dimensions: 152 ft. by 28 ft. 9 in. by 14 ft. 9 in.; armament, three small guns. Diesel propelling machinery supplied by Mirrlees, Bickerton and Day, Ltd., Stockport, Cheshire. Launch, February 18.

M.S. "ORELIA."—Single-screw ore-carrying vessel, built and engined by William Gray & Co., Ltd., West Hartlepool, for Ore Carriers, Ltd., London, E.C.3. First vessel of an order for six. Main dimensions: 407 ft. between perpendiculars by 57 ft. by 33 ft. 4 in.; deadweight capacity, 8,975 tons on a draught of 25 ft. 6 in. Two Gray-Polar five-cylinder Diesel engines, constructed by the shipbuilders' Central Marine Engine Works, coupled to a single shaft through Vulcan hydraulic clutches and reduction gearing, made by David Brown and Sons (Huddersfield), Ltd., Huddersfield. Service speed, 12 knots. Trial trip, February 24 and 25.

M.S. "SOMERSBY."—Single-screw cargo vessel, with accommodation for twelve passengers, built by Sir James Laing and Sons, Ltd., Sunderland, for the Ropner Shipping Co., Ltd., Darlington. Main dimensions: 440 ft. between perpendiculars by 61 ft. 4 in. by 39 ft. 9 in. to upper deck; deadweight capacity, 9,200 tons on a draught of about 26 ft. 2 in. Hawthorn-Doxford six-cylinder opposed-piston oil engine, constructed by R. and W. Hawthorn, Leslie & Co., Ltd., Newcastle-upon-Tyne. Trial trip, March 3.

M.S. "TANTALLON CASTLE."—Single-screw cargo vessel, with accommodation for twelve passengers, built and engined by Harland and Wolff, Ltd., Belfast, for the Union-Castle Mail Steamship Co., Ltd., London, E.C.3. Main dimensions: 465 ft. between perpendiculars by 65 ft. 6 in. by 41 ft. 6 in. to shelter deck; gross tonnage 7,450. Eight-cylinder double-acting two-stroke oil engine. Trial trip, March 4 and 5.

M.S. "BRITISH VISION."—Single-screw oil tanker, built by Joseph L. Thompson and Sons, Ltd., Sunderland, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 515 ft. between perpendiculars by 69 ft. 6 in. by 37 ft. 6 in.; deadweight capacity, about 16,000 tons on a summer draught of 30 ft. N.E.M.-Doxford six-cylinder opposed-piston oil engine, developing 6,800 b.h.p. at 119 r.p.m. in service, constructed by the North Eastern Marine Engineering Co. (1938), Ltd., Wallsend-on-Tyne. Service speed, 13¼ knots. Launch, March 5.

S.S. "STANPOOL."—Single-screw cargo vessel, built by William Gray & Co., Ltd., West Hartlepool, for the Stanhope Steamship Co., Ltd. (Manager: J. A. Billmeir), London E.C.3. Main dimensions: 420 ft. between perpendiculars by 57 ft. 3½ in. by 37 ft.; deadweight capacity, 9,850 tons on a draught of 27 ft. Triple-expansion steam engines working in conjunction with the Bauer-Wach exhaust turbine, constructed by the shipbuilder's Central Marine Engine Works. Steam supplied by three oil-fired cylindrical boilers. Service speed, 12 knots. Launch, March 5.

S.S. "HAUSTELLUM."—Single-screw oil tanker, built and engined by R. and W. Hawthorn, Leslie & Co., Ltd., Hebburn-on-Tyne, County Durham, for Shell Tankers, Ltd., London, W.C.2. Main dimensions: 557 ft. overall by 69 ft. 3 in. by 39 ft. to upper deck; deadweight capacity, about 18,000 tons. Double-reducting geared steam turbines, developing a maximum of 8,250 s.h.p., and two Foster Wheeler water-tube boilers. Launch, March 5.

S.S. "CICERO."—Single-screw vessel for carrying general and refrigerated cargoes, with accommodation for twelve passengers, built by Henry Robb, Ltd., Leith, to the order of Ellerman's Wilson Line, Ltd., Hull, for service to Mediterranean and Scandinavian ports. First vessel of two. Main dimensions: 290 ft. between perpendiculars by 48 ft. 6 in. by 27 ft. to upper deck; deadweight capacity, 2,400 tons on a mean draught of 17 ft. 9 in. Triple-expansion direct-acting surface-condensing marine reciprocating engine, working in conjunction with a Bauer-Wach exhaust steam turbine. Main engine supplied by Swan, Hunter and Wigham Richardson, Ltd., Wallsend-on-Tyne, and the exhaust turbine by Barclay, Curle & Co., Ltd., Whiteinch, Glasgow. Service speed, 13 knots. Launch, March 5.

ACTIVITIES OF UNITED STATES STEEL CORPORATION

The production of steel ingots and castings in the various works of the United States Steel Corporation, New York, during 1953 was higher than in any previous year. The output totalled 35·8 million net tons, against 29·4 million tons in 1952 when production was affected by protracted labour troubles. The previous high record was attained in 1951, when 34·3 million tons were produced. In his review of the year, enclosed in the firm's recently-issued annual report for 1953, Mr. B. F. Fairless, the chairman of the board of directors, states that the Corporation's annual steel-ingot and castings capacity on January 1, 1954, was 38·7 million net tons, which represents just over 31 per cent. of the total reported capacity of the steel industry of the United States.

Dealing with improved production facilities, Mr. Fairless states that at the Pittsburgh works, three batteries of coke ovens are being rebuilt and increased in capacity. The new ovens are due for recommissioning in the second quarter of 1954. A new bucket-conveyor barge unloader is being installed for handling river-borne coal and a modern ingot-mould foundry is being constructed; the latter is also expected to be completed during the second quarter of the present year. At the Chicago works, increased facilities are being provided for the production and recovery of chemicals from coal, including naphthalene. Two batteries of coke ovens are also being rebuilt.

The new completely-integrated Fairless Steelworks, at Morrisville, Pennsylvania, are now in full operation having been completed a little over 2½ years after the cutting of the first sod on March 1, 1951. The products of these works include billets, bars, hot- and cold-rolled sheet and tin-plate.

Among other developments, the American Steel and Wire Division of the Corporation is constructing a blast-furnace having a capacity of 1,350 tons of iron a day. It is anticipated that it will be blown in during the third quarter of 1954. A sinter plant for dealing with blast-furnace flue dust is also to be completed this year. The firm's Michigan Limestone Division is establishing a new dolomitic-limestone quarry in Northern Michigan, with crushing and screening plant and berthing facilities for ships.

An important objective in the supply of iron ore has been realised. The first shipload of iron ore from Puerto Ordaz, Venezuela, arrived at the Fairless works on January 20, 1954. The ore is extracted by the Orinoco Mining Company, a subsidiary concern of the Corporation. Another development which took place in 1953 was the acquisition of an interest in a French company which has exploration rights on a deposit of manganese ore in French Equatorial Africa. Arrangements have also been concluded whereby manganese ore will be supplied to the Corporation from a large undeveloped deposit in Brazil.

The Research and development activities of the Corporation have been marked by the speedy application of new technical information to full-scale operation. Improved blast-furnace performance is now achieved through better coal-washing and coal-blending methods which serve to improve coke quality. The study of transparent models of blast furnaces has given much useful information concerning the flow of gases and the movement of materials at different places in the stack. Scale and small transparent models of an open-hearth furnace have also been utilised to secure new data on the consumption of fuel and the flow of gases.

NAVAL SALVAGE OF THE COMET

A week before British Overseas Airways Corporation resumed their suspended commercial services with the Comet air liner fleet on Tuesday, March 23, there was news of the search for the wreckage of the Comet air liner which crashed off the coast of Elba on January 10. On March 16, a message received by the Admiralty stated that the salvage vessel Sea Salvor had recovered the vital part of the wreckage, the main spar centre section, which measures about 65 ft. in length and 2 ft. 6 in. in width, with several pieces of projecting structure. Later in the week the news came through that the four engines and various other small components had been salvaged and flown back to the de Havilland Engine Company, Limited, for examination. The rotor disc was missing from one engine. Some extracts from a survey of the salvage operations, which was received by the Admiralty before the recovery of the main components, are given below.

The Comet aircraft was known to be at a height of 26,000 feet climbing to 30,000 somewhere south-east of the island when the accident occurred. This was undoubtedly sudden and final; a wireless message which was being transmitted by the Comet to a B.O.A.C. Argonaut aircraft at the time was broken off without explanation.

The only concrete evidence which was immediately available as to the position of the crash was from various fishing boats who proceeded to the scene and recovered 15 fatal casualties out of a total of 35 who were aboard the aircraft at the time. The position given by these fishermen was 12 miles south of Calamita Point. Later information showed that this was too far south. The depths were between 360 and 600 feet.

At 10.30 p.m., on Saturday, January 16, 1954, the Commander-in-Chief, Mediterranean, received the following signal from the Admiralty: "Endeavour to locate and salve the Comet."

There was an immediate requirement for an Asdic-fitted ship to search and also act as headquarters ship. A Danlayer was required to mark exactly with buoys the various search areas. A mooring vessel was necessary to lay anchors and moorings, and finally a salvage vessel was required to pick up these moorings and salve the Comet. Television was also essential to assist the Asdics in identifying and recognising the wreckage when found.

MALTA DOCKYARD

These requirements, all met within a few days, involved work at full pressure by the Dockyard in Malta, preparing the salvage vessel for this specialised task and preparing the heavy mooring gear. Special stores had to be embarked in all ships and the television equipment, observation chamber and special grab were all flown out from the United Kingdom.

On Monday, January 18, H.M. Ships Wrangler (Captain C. M. Parry, C.V.O., O.B.E., R.N.), an anti-submarine frigate, and Sursay (Lieutenant-Commander H. Stern, R.N.), a Danlayer, sailed from Malta. They were followed a little later in the week by H.M.S. Barhill (Lieutenant S. C. Smith, R.N.), a Boom Defence Vessel for laying moorings, and the Royal Fleet Auxiliary Sea Salvor (Captain J. R. Hayward), a specialised salvage ship.

By January 23, 1954, all ships had arrived in Elba. Five local fishing boats were chartered to assist.

Various objects were detected by H.M.S. Wrangler's Asdics and some by fishing trawlers snagging heavy objects on the bottom with their trawls. On January 21, 1954, the first wreckage was recovered by the trawler Favilla, consisting of some aluminium and a valise with B.O.A.C. markings. Unfortunately it was impossible to tell the exact position at which the objects entered the trawl, so this did not establish the Comet's position. Ordinary fishing boats also recovered various objects and small pieces of wreckage, and it soon became apparent that the wreckage was scattered over a large area, and that the area was the site of an old war-time minefield.

Early in February, a television camera was installed in H.M.S. Wakeful which subsequently played a great part in the identification of objects on the bottom.

The five Italian fishing trawlers developed a sweeping technique by dragging a wire along the bottom with the ships working together in pairs. The wire, thus dragged along the bottom, snagged any sizeable object, but unfortunately most of the objects snagged in this way proved to have been part of the minefield or otherwise related to it.

On February 10, the trawlers working in pairs snagged an object five and a half miles south of Calamita Point and H.M.S. Wakeful attempted to identify it by television. On the third day, Friday, February 12, there suddenly floated across the television screen an unmistakable piece of aircraft wreckage.

Owing to bad weather, it was not until Friday, February 19, that R.F.A. Sea Salvor moored over the wreckage. The diver followed the trawl wire down. The large grab was sent down and the ship was worked on her wires at the diver's request until the grab was exactly over the target. It was immediately lowered and then up it went with the first recovery. R.F.A. Sea Salvor stayed on her moorings for a week and during that time she made 15 separate recoveries with her grab of pieces of wreckage.

On one occasion the ship had to make 70 "movements" (by working the wires) before the grab was exactly over a piece of wreckage. The grab cannot be moved by traversing its derrick without moving the whole ship, since if this were done the grab would be continually moving out of the diver's vision.

Another difficulty is that once R.F.A. Sea Salvor is moored, it is impossible for the frigate with her Asdics and television to help her because of the danger of fouling the mooring wires. This was attempted on one occasion, but resulted in damage to the television camera. Nor can the trawlers sweep near her, so that once the piece of wreckage is recovered which had the trawl wire round it, any further recoveries are by groping literally in the dark, the ship being moved by its wires and the diver and television camera together trying to sight wreckage within their ten-foot vision.

At the end of seven days on her moorings, R.F.A. Sea Salvor unmoored. Another examination of the area was started by the trawlers. Another object was snagged 500 yards from the original object and the difficult work of relaying the moorings and remooring R.F.A. Sea Salvor continued. In the meantime the trawlers continued to bring up small pieces from almost every part of the aircraft.

It must be the first time a salvage operation has been attempted in winter to recover pieces of aircraft in depths between 360 and 600 feet, which may cover an area of seven miles. British equipment of all types has proved to be first class. Up to date the operation has covered 100 square miles, has involved the expenditure of over 2,000 tons of fuel, the steaming of over 10,000 miles, and the laying of 276 buoys.

BOOK REVIEWS

Rigid Frame Formulas. By DR.-ING. A. KLEINLOGEL. Foreword by PROFESSOR L. F. MORRISON. First American Edition. *Frederick Ungar Publishing Company, 125 East 24th-street, New York 10, U.S.A.* (10·00 dols.); and *Crosby Lockwood and Son, Limited, 39 Thurloe-street, London, S.W.7.* (75*s.*)

It is logical, as it has long been inevitable, that the systematic tabulation of the solution of constructional design problems should be extended from the basic components, such as rolled-steel sections and rivets, to the structure itself, as Professor Kleinlogel was one of the first to recognise over 40 years ago. So little attention, however, has been paid to this important service to the engineering profession, that Kleinlogel still stands virtually alone as a purveyor of ready-to-use formulæ for the structural engineer. In some circles, indeed, there seems to be an implicit assumption that an enterprise of this kind is not a proper study for the engineer with research interests, and that it is more profitable to develop new methods of solution than to extend the tally of solved problems.

Readers familiar with Kleinlogel's work should note that the present volume does not include his extensive analysis of the double portal, but they will nevertheless appreciate that the book represents very good value, in that one or two solutions alone would pay for it in time saved in the design office. There can be no doubt that the English-speaking engineer will prefer to use this translation, rather than the original German text, since results presented in terms of familiar symbols can be used more rapidly and with greater confidence than an unfamiliar script.

The question may well be asked whether this book, which is throughout based on the traditional elastic theory of structures, does not appear rather late in the day, in view of the effort which has in recent years been devoted to developing methods of design which take account of plasticity, especially now that such methods are already beginning to leave the purely academic and experimental stages. Quite apart from any consideration of the respective philosophies of the elastic and the plastic systems of design, it is not unlikely that in the long run the two systems will be found to be complementary rather than competitive. It is likely that this book will still be in use when a similar catalogue of plastic solutions has become available.

The solutions cover about 30 different geometrical forms which, with a variety of boundary conditions in each case, comprise 114 separate rigid frames, including variable stiffness parameters. For each such frame a number of different types of loading are considered, and in fact over 1,600 special cases are analysed, many of which include influence lines for the effects of moving loads. For each of these special cases, the form of the bending-moment diagram is illustrated diagrammatically.

This profusion of illustration, though it is no doubt a help to the user, takes far more space than would the mere tabulation of the author's results. This is perhaps a small point in the immediate context, but in view of the possibility of using electronic computers to extend very greatly the range of frameworks for which corresponding solutions could be compiled, the problem of a more concise, if slightly less readable, method of tabulation seems to merit consideration. For although several of the author's designs are of considerable practical importance, there is still a wide field which might usefully be covered, especially perhaps in respect of multi-storied frameworks. In an illuminating foreword to what he calls "this remarkable book," Professor L. F. Morrison, who is Professor of Applied Mechanics in the University of Alberta, refers to the possibility of solving more highly redundant frames with the help of these solutions. This is, of course, a feasible proposition, but it must be remembered that since the resolution of a framework with six redundancies entails eight or ten times the labour of unravelling one with only three, the work of combining two third-order solutions may be expected to be six or eight times that of solving one from the basic elastic equations. On the other hand, Professor Morrison makes the very important point, so frequently overlooked, that before any analysis can be made of a statically redundant structure, there must be a designer's estimate of the proportions of the frame members that are likely to prove adequate in the light of the completed analysis. Thus, if the designer has a problem which does not exactly correspond with any recorded precedent, he can only hope to make a reasonable first estimate on the basis of related experience. In this book, Kleinlogel has contributed greatly to the general enlargement of such experience, in addition to having provided many solutions of particular problems.

Tables of Normal Probability Functions $\frac{1}{\sqrt{2\pi}} e^{-\frac{x_2}{2}}$ **and** $\frac{1}{\sqrt{2\pi}} \int_{-x}^{x} e^{-\frac{\alpha^2}{2}} d\alpha$. National Bureau of Standards Applied Mathematics Series No. 23. *The Superintendent of Documents, United States Government Printing Office, Washington, 25, D.C., U.S.A.* (2·75 dols.)

The above functions, denoted respectively by Q (x) and P (x) in the introduction by Arnold N. Lowan, are of fundamental importance in statistics being immediately adaptable to such practical purposes as testing the significance of a deviation in a normally distributed variate and in fitting normal distributions to observations. Originally published in 1942 these tables were reprinted, with a few misprints in the arguments corrected, in 1948 and the continued demand for copies is responsible for the present re-issue.

In the main Table I the values of Q (x) and P (x) are tabulated for $x = 0\ (0{\cdot}0001)\ 1\ (0{\cdot}001)\ 7{\cdot}800$ (various) 8·285 to 15 decimal places while the supplementary Table II gives values of Q (x) and of $(1 - \mathrm{P}(x))$ to 7 significant figures in the range of x between 6 and 10 at intervals of 0·01. For larger values of x the functions Q (x) and P (x) converge rapidly to 0 and 1, respectively. Methods of direct and inverse interpolation are described in the introduction and illustrated by means of examples. There is also a note on the problem of approximate arguments enabling one to decide how many decimal places (or significant figures) may be retained in the computed value of the function on the basis of a given uncertainty in the argument and an asymptotic expansion that can advantageously be used for the computation of P (x) for large values of x.

A useful bibliography of important original tables of closely related functions is appended to the introductory section. Apart from their direct usefulness the high accuracy and extensive range of these tables render them well suited for the computation of further tables of functions related to the normal distribution.

Manual of Mechanical Power Transmission. Third revised and enlarged edition. *Trade and Technical Press, Limited, 65-66 Chancery-lane, London, W.C.2.* (51*s.* post free.)

The branch of mechanical engineering which deals with mechanical power transmission is one with which the plant engineer is frequently concerned and he, in particular, should find the third edition of this manual of practical value.

Each section of this edition has been revised and the overall size of the pages has been increased to permit the use of a larger and more readable type face. The titles of the principal sections are bearings, flat belting, belt joining, chain drives, compressed air, couplings and clutches, gears, hydraulic transmissions, pulleys, rope drives, V-belts and V-ropes. A brief buyers' guide is given. The largest section is that dealing with gears and the first chapter in this section discusses the factors affecting their choice. Tables, formulæ and diagrams are included to assist in making the selection.

TRADE PUBLICATIONS

Electrolytic Capacitors. The Plessey Co., Ltd., Ilford, Essex, have published a booklet describing their range of electrolytic capacitors and including a section on design details. Capacitor sizes range from 2 to 8,000 mf, for voltages up to 450; four types of casing are available. The booklet is available only to manufacturers.

Electricity Meters. New and reconditioned meters are listed in a catalogue issued by the Electric Meter Co., Castle Circus House, Torquay, Devonshire. Types available include quarterly and prepayment meters, continuous, single or three-phase currents up to 1,000 amperes.

Starters for Small Motors. J. A. Crabtree & Co. Ltd., Lincoln Works, Walsall, have published a booklet describing their new range of push-button starters for motors up to ½ h.p. The starters are fitted with thermal overloads and can be supplied for either surface or flush mounting.

Sound Equipment for Schools. A series of leaflets issued by the Clarke & Smith Manufacturing Co., Ltd., Melbourne Works, Wallington, Surrey, gives particulars of sound equipment particularly designed for schools. Record players, tape recorders and amplifiers are included.

Terminal Blocks. "Kabi" multi-way terminal blocks and strips are described in a leaflet issued by Precision Components (Barnet), Ltd., 13 Byng-road, Barnet, Hertfordshire. The maximum current rating is 60 amperes.

Water Repellant for Masonry. We have received a leaflet from Allweather Paints Ltd., 36 Great Queen-street, London, W.C.2, concerning "Pitan" water repeller. It is a colourless waterproofing and water repelling material based on a silicone resin and suitable for above-ground masonry including brick, asbestos and concretes but not for plaster finishes.

Concrete Mixers. Blaw Knox, Ltd., 94 Brompton-road, London, S.W.3, have sent us five leaflets describing four concrete mixers and a universal batch weigher which they are marketing. Three of the mixers are small 3½-cub. ft. models, but the fourth is the Rex 285 having a drum capacity of 40 cub. ft. of dry materials. The batch weigher is designed to serve two mixers (7 to 14 cub. yd. models) standing side by side.

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BOOKS RECEIVED

Kempe's Engineer's Year-Book for 1954. In two volumes. Edited by C. E. PROCKTER under the direction of B. W. PENDRED. *Morgan Brothers (Publishers), Limited, 28 Essex-street, Strand, London, W.C.2.* (75*s.*)

Canadian Conference on Prestressed Concrete, 1954. *The Director, University Extension, University of Toronto, Simcoe Hall, Toronto 5, Ontario, Canada.* (2.50 dols.)

Vermiculite. By O. S. NORTH and H. P. CHANDLER. United States Department of the Interior, Bureau of Mines Information Circular 7668. *Bureau of Mines, Publications Distribution Section, 4800 Forbes-street, Pittsburgh, Pennsylvania, U.S.A.* (Free on application.)

Procedures in Experimental Metallurgy. By A. U. SEYBOLT and J. E. BURKE. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, U.S.A.*, and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (56*s.*)

Essentials of Engineering Thermodynamics. By HERMAN J. STOEVER. *John Wiley and Sons, Incorporated, 440 Fourth-avenue, New York 16, U.S.A.*, and *Chapman and Hall, Limited, 37 Essex-street, London, W.C.2.* (36*s.*)

Industry and Science. A study of their relationship based on a survey of firms in the Greater Manchester area carried out by the Manchester Joint Research Council, 1950–53. *Manchester University Press, 316-324 Oxford-road, Manchester, 13.* (12*s.* 6*d.*)

The Rheology of Non-Aqueous Suspensions. By P. J. RIGDEN. Road Research Technical Paper No. 28. *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.*)

Construction of Esso Refinery, Fawley. A Study in Organisation. By A. P. GRAY and MARK ABRAMS. *British Institute of Management, Management House, 8 Hill-street, London, W.1.* (3*s.* 6*d.*)

Tables of Circular and Hyperbolic Sines and Cosines for Radian Arguments. United States National Bureau of Standards, Applied Mathematics Series No. 36. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (3 dols.)

The Engineering Outlook—12

CONSTRUCTIONAL AND GENERAL ENGINEERING

SMALL INDUSTRIES EXPANDING

IN the final article in the "Outlook" series, it is customary to draw a general conclusion about the prospects of the engineering industry as a whole, and also to discuss briefly the fortunes of some of the sections not so far covered. This task is particularly difficult in 1954, for so many factors are uncertain that a prediction becomes simply an expression of optimistic hope or pessimistic anxiety, according to the temperament of the forecaster. Above all, there is the uncertainty about the future trend of world trade engendered by the continuing fall in economic activity in the United States. There is also little assurance that the high volume of sales of consumer goods on the home market will be long sustained, and it remains to be seen whether or not British industry will buy plant and machinery on a scale sufficiently great to raise productivity and keep British goods competitive in world markets. There is no uncertainty about the increasing strength of foreign competition, and any rise in British wage costs which are not matched by a comparable increase in productivity will be a considerable handicap.

PROSPERITY DEPENDENT ON ENGINEERING EXPORTS

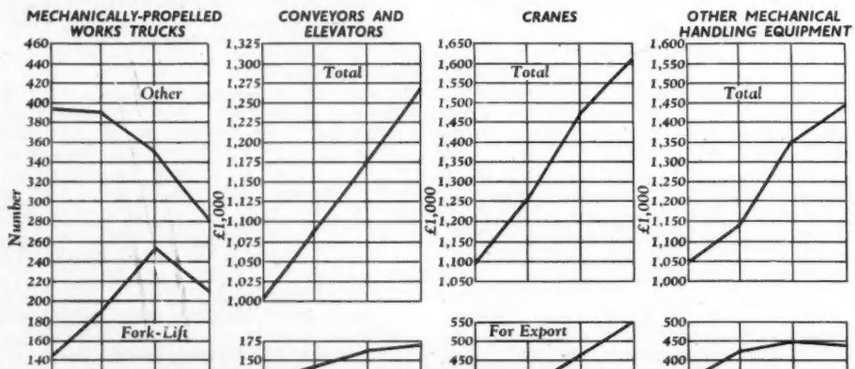
The Court of Inquiry into the engineers' pay dispute did not think that the increase of about 5 per cent. in engineers' wages, which they considered justified, could itself have disastrous effects, though they recognised that, if it proved to be part of a more general movement of wages costs and prices, the whole economy might be undermined. Nevertheless, the need for restraint is particularly urgent in the engineering industry, for the continuing prosperity of the United Kingdom is more than ever dependent upon a high volume of the country's engineering exports.

It may well be desirable, therefore, that there should be some modification of the wage-bargaining system in engineering as well as in many other industries, so that wage awards will not depend simply upon the relative strength of the bargaining parties, but will take account of the national interest. Certainly, this is the view of the Court of Inquiry, who recommended that an impartial and authoritative body should be appointed to consider wages claims "and the complex and sometimes conflicting economic arguments which surround them," and "to form a view upon their implication for the national economy and our ability to maintain our present standards."

Despite all the difficulties, the year has begun well for many sections of the engineering industry. The total exports of engineering products in January reached £89 millions, which compares with £82 millions in January, 1953, and a monthly average of only £81 millions throughout last year. It would be unwise, however, to be too optimistic about this further advance of the recovery which began in the closing months of 1953.

An analysis of British exports in the March number of the *Bulletin for Industry*, prepared by the Information Department of the Treasury, shows that an increase of £71 millions in the last six months of 1953, compared with the first six months, was due partly to an increase in exports of aircraft, arms and ammunition and petroleum products, and that three-quarters of it was accounted for by higher sterling exports, mainly to Australia and New Zealand. Where German competition has been encountered, the increase in British exports has been comparatively small.

Especially serious has been the growing indebtedness to the European Payments Union, which now amounts to £200 millions, compared with a surplus of £51 millions at the end of June, 1953. While British exports to Western Europe rose by only £3 millions in the second half of 1953, German exports rose by about £49 millions, and much of the increase in German exports represented engineering products. The dollar markets, where British products have been holding their own in competition with the German, have lately been contracting, though British motor cars have been making considerable headway in the United States. The trend of machinery exports in the most important markets during the past three years is shown in Table I on this page, taken from the *Trade and Navigation Accounts*.



Mechanical-handling equipment made in the United Kingdom: monthly averages during the past four years. Known plans for factory reorganisation suggest an increase in demand for this equipment during 1954.

TABLE I. UNITED KINGDOM: EXPORTS OF MACHINERY. VALUE (£1,000)

—	1951	1952	1953
To Gold Coast	2,226	3,120	3,502
„ Nigeria	2,987	4,054	4,344
„ Union of South Africa	32,094	35,180	38,253
„ Northern Rhodesia	1,746	3,151	3,542
„ Southern Rhodesia	4,496	5,691	4,974
„ Kenya	3,525	4,309	4,832
„ Aden	269	1,727	4,205
„ Bahrein, Qatar and Trucial Oman	901	1,287	2,130
„ Kuwait		2,150	4,101
„ India	34,169	35,625	33,767
„ Pakistan	8,131	10,292	9,221
„ Malaya	7,662	9,967	8,505
„ Australia	47,284	47,575	41,437
„ New Zealand	11,185	15,437	13,554
„ Canada	13,334	17,514	18,836
„ British West Indies	4,074	4,516	4,771
„ Irish Republic	10,477	10,834	10,719
„ Sweden	11,604	10,751	9,567
„ Norway	5,361	7,951	8,320
„ Denmark	3,830	3,958	3,544
„ Western Germany	2,773	4,241	5,030
„ Netherlands	13,034	12,896	14,035
„ Belgium	8,840	9,081	9,041
„ France	11,493	11,041	13,598
„ Portugal	4,177	3,969	3,337
„ Spain	3,268	4,693	5,667
„ Italy	6,200	12,413	12,025
„ Turkey	5,096	10,390	5,311
„ Egypt	6,205	5,201	3,515
„ Iraq	2,437	3,917	5,257
„ Thailand	1,981	3,066	3,410
„ United States of America	7,147	9,283	11,646
„ Venezuela	3,415	4,089	5,162
„ Brazil	14,272	17,540	6,411
„ Other countries	67,513	74,934	68,461
Total	£363,206	421,843	404,630

TRADE WITH RUSSIA AND CHINA

The unfavourable influences will be of less consequence should it be possible to develop trade with Russia and China. Sir Winston Churchill recently stressed the advantages of this "friendly infiltration" when he said, "The more the two great divisions of the world mingle in the healthy fertile activities of commerce, the greater is the counterpoise to purely military calculations." Rapid developments are scarcely to be expected, however; the agreement of the United States authorities is necessary for a relaxation of the embargo on the numerous classes of goods which may not be exported to Russia, and this may not be easily secured. Moreover, the business men who lately returned from Moscow have reported that the Russians drive a hard bargain. Since the cost of sending trade missions must be fairly considerable, there may be little in the lure of Russian gold, particularly if the Government later decide that, for strategic reasons, many of the orders should not be accepted.

Without a successful solution to the export problems, there can be no healthy home market. The high volume of home sales of cars, domestic appliances, etc., would have been impossible in 1953 if the terms of trade had not moved in favour of British exports. While a counter movement in 1954 is unlikely, the national income of the United Kingdom is not large enough to permit the luxury of increased consumer spending. Should this be stimulated by inflationary pressures generated by higher wages or increased Government expendi-

ture, it would become impossible to sell British goods at competitive prices in deflationary world markets.

REVISION OF DEPRECIATION ALLOWANCES?

The Chancellor of the Exchequer cannot, therefore, afford to budget for a deficit in April, and tax reliefs for the consumer are out of the question. Above all, financial policy in 1954 will have to be directed towards the encouragement of saving, so that it may be possible to undertake the increased industrial investment without which higher productivity and higher real incomes will not be achieved. Since little can be done to revive the diminished flow of personal savings, it seems desirable that encouragement should be given to company savings, upon which the main burden of investment falls. A revision of depreciation allowances would certainly be most helpful, for re-equipment presents great difficulties in such industries as shipping, where the cost of replacing capital assets is considerably in excess of their original cost.

During the past few years, an increasing proportion of the available resources has been absorbed by housing and defence; investment by private industry, on the other hand, has declined, though there is some evidence that the fall was arrested in the second half of 1953. Shortage of resources is not, of course, the only factor responsible for the low volume of industrial investment; the only reaction to difficult markets by too many manufacturers, especially in some of the older traditional industries, is to cut their outlay on new plant and machinery. The outlook for these industries can rarely be so poor that higher efficiency and more competitive prices would not stimulate sales. If, in fact, the industries are past redemption, it is preferable that the manpower and financial resources which they command should be quickly transferred to the developing industries which can make good use of them. Such re-organisation would greatly assist the engineering industry to supply the plant and machinery which would make the greatest contribution to raising productivity in the United Kingdom.

MECHANICAL HANDLING AND AUTOMATIC PROCESSES

The experience of British manufacturers of mechanical handling plant is indicative of some of the difficulties to which the engineering industries are subject. As may be seen from the graphs on the opposite page, output has increased considerably since 1949, but there was a disquietening drop in the production of works trucks in 1953, and, though the value of the output of other types of mechanical handling equipment was a little higher, the volume was probably no greater than in 1952. The advantages of fork-lift trucks are generally recognised, and the use of pallets is making an increasing contribution to speeding the transit of goods; nevertheless, a slackening demand reduced the output of fork-lift trucks to fewer than 2,600 in 1953. Even in the record year 1952, it was only about 3,000. Since the annual output of one manufacturer alone in the United States is 25,000, there is obviously scope for a considerable improvement in the United Kingdom.

Whereas the demand from the motor-vehicle industry for mechanical equipment has been strong (and motor-vehicle manufacturers are constantly exerting pressure on the suppliers of their components to install labour-saving methods), many other industries have been unwilling to undertake the costly re-organisation of plant and layout which is often necessary before mechanical handling equipment can be profitably installed. Fortunately, there is evidence that more re-organisation schemes are planned for 1954, so that the sales of mechanical handling plant should increase.

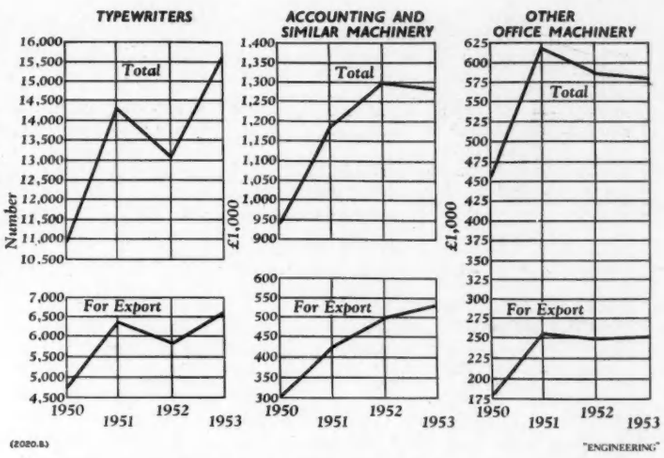
The ultimate goal of all progress in productivity is the fully-automatic factory, and British makers of instruments have already done much to make this possible. The Department of Scientific and Industrial Research recently announced that the possibility of performing elaborate machining operations by an entirely automatic industrial process had been brought closer by the development of a simple system of precise measurement. The National Physical Laboratory, who are assisting in work which is being undertaken by Ferranti Limited, believe that, when the work is completed, it will be possible for complicated operations to be carried out by machines according to instructions stored in a tape machine, and that the automatic factory will then be in sight.

Steady progress continued to be made with electronic control gear generally. The General Electric Company, for example, report that the efficiency of the Autopaster for rotary printing presses has been greatly increased by the use of electronic gear, which enables the speed of an expiring reel of newsprint to be so accurately matched that a new reel can be spliced without slowing the press. In the United States, considerable publicity has been given to the advance of "automation." The General Electric Company of the United States, who appear to have been working on much the same lines as the British firm, claim to have evolved a system of controlling a milling machine by feeding instructions on a magnetic tape. After a human operator has guided the machine through the initial operation, it can be repeated as required by the machine. Automatic assembly lines are becoming increasingly common. One of the latest is that of the Curtiss-Wright Corporation, which requires little or no human assistance in the assembly of turbo-compound aircraft engines.

OFFICE MACHINERY

Rapid progress has been made with the development of electronic computers, both in the United States and in the United Kingdom. Their high cost still restricts their field of application, and as yet all but the simplest tend to be concentrated mainly in research institutions. One, installed in December at Wayne University, Detroit, by the Burroughs Corporation, cost 500,000 dols. Another, used by J. Lyons and Company at Cadby Hall for calculating the wages of 1,700 employees, cost £150,000.

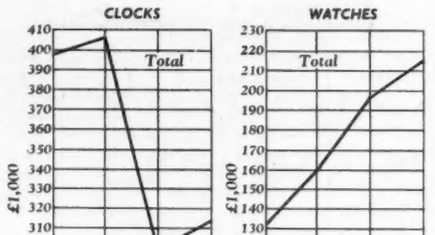
A computer of the type installed by Ferranti, Limited, at Manchester University, which can store 10,000 facts in its electronic "memory," would cost about £90,000. A smaller model, with a memory for 1,000 facts, such as that recently developed by Elliott Brothers (London), Limited, can be made for £30,000. International Business Machines, Limited, have recently



Office equipment: the monthly average outputs since 1950. Though output of accounting machines fell somewhat during 1953, a recovery has begun and the output of these and other office equipment is expected to reach a high level in 1954.

TABLE II. UNITED KINGDOM: EXPORTS OF SOME INDUSTRIES, CLASSIFIED AS "GENERAL ENGINEERS." VALUE (£1,000)

—	1938	1950	1951	1952	1953
Air and gas compressors and exhausters	573	3,803	4,324	5,284	4,975
Boot and shoe machinery	165	714	718	902	885
Cement-making machinery	84	1,707	1,506	1,796	1,431
Centrifugal drying machinery	209	397	566	769	817
Concrete-mixing machinery	129	1,011	1,182	1,389	1,280
Condensers	296	492	654	599	784
Cranes, hoists and other lifting machinery	1,597	8,230	7,642	10,754	12,188
Dairy machinery	235	1,823	1,921	1,883	1,121
Excavating and similar digging machinery	681	6,859	9,824	14,250	16,147
Fans, power-driven	—	1,484	2,047	2,515	2,726
Food preparation and sterilising machinery	376	4,584	4,121	5,010	4,510
Furnace plant	357	1,312	1,064	1,518	1,464
Gas and chemical machinery	329	3,143	2,032	2,207	2,232
Grain-milling machinery	326	2,465	2,122	2,477	2,060
Hydraulic machinery	253	538	1,255	1,357	932
Laundering and dry-cleaning machinery	149	5,121	8,908	7,113	6,030
Lawn mowers	138	1,447	1,835	1,651	1,539
Office machinery	638	5,968	9,245	9,700	10,769
Packing, packeting and labelling machinery	188	2,797	3,117	3,386	2,883
Portable power tools	345	2,997	3,550	3,825	3,802
Printing and bookbinding machinery	1,039	10,013	9,816	9,749	8,862
Pulp and papermaking machinery	729	2,054	2,071	3,204	4,112
Pumps	1,561	8,344	9,819	13,299	13,511
Road rollers	253	1,202	1,072	1,570	1,607
Sewing machines and parts	1,262	5,998	7,032	8,315	7,297
Tobacco and cigarette-making machines	522	1,945	2,419	2,880	3,390
Sugar-making and refinery machinery	566	2,337	2,327	2,819	2,437
Weighing machinery	259	1,306	1,512	1,646	1,609
Welding machinery	—	2,422	2,714	3,677	3,747
Woodworking machinery	231	2,053	2,200	2,517	2,078
Ball and roller bearings	646	2,531	2,471	3,176	3,620
Ophthalmic instruments	442	565	853	648	696
Medical and surgical instruments	465	2,186	2,492	2,432	2,377
All other scientific instruments	903	6,847	7,796	9,242	9,969
Clocks and watches	104	1,376	1,350	1,123	1,049
Total	16,050	108,071	123,587	144,682	144,936



The revived watch and clock industry in the United Kingdom is competing successfully with foreign manufacturers. The graphs show the average monthly value of output in the United Kingdom in recent years.

introduced a new triple-unit computer for office use, which can perform 14,000 operations a minute, but even more interesting is their "electronic translator," which will translate a message fed into it in one language into another in proper word order. Public demonstrations, using Russian and English, have been given of this machine, which at present has a vocabulary of 250 words.

Oddly enough, the output of accounting and similar machinery, alone among all the categories of office machinery, fell off in 1953 (see the graphs on page 395); but there has been a very pronounced recovery since the last quarter of the year, and with the new factory of International Business Machines, Limited, in operation, production should reach a very high level in 1954. This factory, which will also produce typewriters and time-recording equipment, will add greatly to the strength of the young and growing British office-machinery industry. Including the large American concerns who have set up manufacturing subsidiaries in the United Kingdom, there are now 200 makers of office machinery, employing about 25,000 workpeople. Exports (see Table II, on page 395, from the *Trade and Navigation Accounts*) amounted to £10·8 millions, of which £3·6 millions was derived from accounting machines. Exports of typewriters had fallen off somewhat in 1952, but the recovery in the second half of 1953 has been remarkable; by October, 1953, the value of the output for export was running at twice the rate achieved in 1952. An assessment of the contribution which the industry is making to British earnings of foreign exchange must also take into account the savings which have resulted from the reduction in imports of office machinery. In 1951, these amounted to £1·1 millions; in 1953, they had fallen to £528,000, and much of this was accounted for by parts imported from the United States for assembly in the United Kingdom.

CLOCKS AND WATCHES

Another industry responsible for large earnings of foreign exchange, from products which formerly had to be mainly imported, is the manufacture of clocks and watches. Though, as may be seen from the graphs at the top of this column, the output in 1953, was not much higher than in 1952, sales had recovered remarkably by the end of the year. Exports rose somewhat, but the competition from cheap German products is increasing. Formerly the United Kingdom was the principal German market, but since this is now greatly diminished, imports from Germany being restricted by a quota and a tariff of 33·3 per cent., competition in other markets is all the more intense. The capacity of the German industry in the Black Forest is now greater than it has ever been, and the workpeople, whose wages are 40 per cent. below the British, have a basic working week of 55 hours. British manufacturers, however, can rely upon their modern production methods to keep them competitive. The factory of S. Smith and Sons (England), Limited, at Wishaw, which produces over 50,000 clocks a week, accounts for half the output of alarm clocks in the United Kingdom. An associated company, the Anglo-Celtic Watch Company, have a factory at Ystradgynlais which can produce more than a million watches a year. It is thought to be the largest production unit for complete watches in the world.

The British output of high-quality fully-jewelled lever watches is still on a comparatively small scale, but the quality of those which are being produced from Smith's Cheltenham factory, with the help of machinery leased from Switzerland, is claimed to equal that of the best Swiss watches. Useful publicity has been obtained following the successful employment of these watches on the Everest expedition, and sales have been brisk.

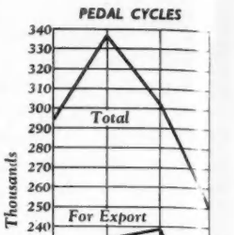
It is, however, no easy task to secure a significant share of the total market for such watches in competition with the Swiss. Heavy outlay on special plant of great accuracy is required, as well as highly-trained craftsmen, and it would take many years to establish a reputation comparable with that built up by the Swiss manufacturers over a century. Swiss watches, the imports of which are limited at present by quota and tariff to £2·6 millions per annum, are therefore likely to continue to find a good market in the United Kingdom.

Two recent developments in the manufacture of clocks and watches are worthy of note. A prototype of a pendulum clock has been demonstrated which can be continually adjusted by a radio signal, and can thus assure the complete accuracy of chronometers in factories, observatories and ships; and an "electronic" watch, invested by the French Lip Company, is to be marketed in the United Kingdom by a subsidiary of Ingersoll, Limited. This watch, which is driven from two batteries, each with a volume of only 0·12 cubic inches, may be the forerunner of the entirely wheelless watch. The number of jewelled bearings has already been reduced to seven as against 16 or 17 in conventional watches of comparable accuracy. When they are first marketed in 1954, the price of the new watches is expected to be between £30 and £35, but some reduction may be possible later.

SET-BACK TO BICYCLE EXPORTS

British exports of cycles experienced a set-back in 1953, when they fell by nearly £7 millions to £23·9 millions. There was some increase in home sales, stimulated by a reduction in prices, but since exports account for 70 per cent. of the total, the output fell considerably, as may be seen from the accompanying graph. The fall in sales to the primary-producing countries was marked; exports to Malaya fell by nearly £2 millions to £1·2 millions, while exports to the Belgian Congo and Indonesia, which had totalled £2·6 millions in 1952, were more than halved. Moreover, the growth of local manufacture of cycles has greatly reduced exports to India, South Africa, Ireland and Brazil.

British companies, of course, are deriving revenues from their manufacturing subsidiaries abroad, but Raleigh Industries, Limited, report that the output of their South African subsidiary has been restricted through inability to obtain sterling licences for the importation of certain

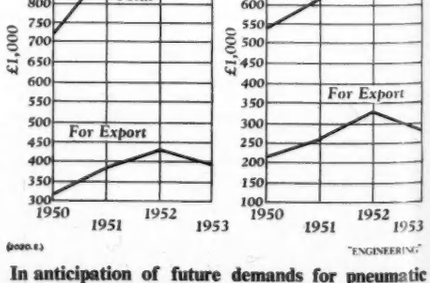


Monthly average output of pedal cycles in the United Kingdom. Exports to the United States have continued to be considerable, but local manufacture in India, South Africa and elsewhere has reduced the numbers being made in the United Kingdom.

essential parts. It was intended that eventually these should be made in South Africa, but the manufacturing programme has now had to be accelerated. Sen-Raleigh Industries of India have now achieved their scheduled output of Robin Hood cycles, and the manufacture of other Raleigh, Rudge and Humber models is now beginning. Irish Bicycles, Limited, have now achieved full output, and since they are now supplying the major part of the demand for cycles in Ireland, British exports fell to only £360,000 in 1953. Raleigh Industries have recently further strengthened their position in the cycle-manufacturing industry by acquiring Associated Cycle Manufacturers, Limited, of Coventry. The manufacture of "Three Spires" and "Triumph" cycles, the output of which is between 50,000 and 60,000 per annum, is to be transferred to Nottingham.

Foreign cycle manufacturers have experienced even more serious difficulties than the British; the three main Japanese makers paid no dividends in three half-year periods to September, 1953, when exports had fallen to a monthly average of 350,000 dols., compared with an average of 609,400 dols. in 1952. The prices of Japanese bicycles, which were once about one-third higher than the British, have now been greatly reduced, and the Japanese industry, which can produce about 2·5 million cycles per annum, will offer keener competition in 1954.

Fortunately, markets for cycles have shown considerable improvement recently, and the volume of sales in the United States has been very encouraging. In 1953, 402,000 British bicycles, valued at £3·6 millions, were sold in the United States, compared with only 185,200 in 1952. If the fall in economic activity in that country can be arrested, the prospects for a further advance are bright. Certainly, the American cycle



In anticipation of future demands for pneumatic tools, manufacturers are increasing their capacity. The figures are average values of monthly outputs.

manufacturers appear to believe so. They are reported to be planning to make a second approach to the Tariff Commission with a plea for higher tariffs, on the ground that, whereas the total sales of bicycles in the United States are expected to fall by 10 per cent. in 1954, imports are likely to rise from 600,000 to 900,000 units. German manufacturers, who have been very successful with their balloon-tyred bicycles, are also concerned, but the British manufacturers have been mainly responsible for increasing the proportion of sales accounted for by imported bicycles in the United States, from 3 per cent. in 1949 to 20 per cent. in 1953.

Since no other industry in the United States has suffered so severely from foreign competition, the American manufacturers believe they have a much stronger case than in 1952, when the Tariff Commission rejected their application on the ground that the industry's production and profits were rising, as well as imports. British lightweight bicycles are not, however, altogether directly competitive with American-built machines, which are sold mainly to children and are designed for rough handling. United States manufacturers make some lightweight bicycles, but these cost from 10 to 15 per cent. more than the British, and their quality is said to be inferior. One of the five principal United States firms recently stopped producing their own lightweight model and are now marketing a British one. No United States manufacturer has yet evolved a successful three-speed gear, and nearly all of those which are fitted are of foreign manufacture, carrying an import duty of 30 per cent.

NEED FOR MORE PORTABLE POWER TOOLS

Compressed air has an important contribution to make to raising British productivity; it is to be hoped, therefore, that the fall in output of compressors and power tools in 1953, indicated in the graphs opposite; was purely temporary. In the United States, portable pneumatic tools have made very rapid headway; sales have increased two and a half times since 1946, and in aircraft manufacture and in foundries pneumatic tools are now more commonly used than electric. In motor-vehicle manufacture, the number of tools of both types in use is about equal. In anticipation of a growing demand for power tools of both types in the United Kingdom, British manufacturers are increasing their capacity. Armstrong Whitworth and Company (Pneumatic Tools), Limited, are going ahead with plans to become the largest manufacturers of power tools in Europe. The first phase of the programme was the establishment of a link with the Thor Power Company of the United States three years ago, and the second was the erection of a new factory at the West Chirton Trading Estate, North Shields. This was opened in November, and in 1954 it is proposed to add 25 new power tools to the company's range. These will include the first high-frequency electric tools to be made in the United Kingdom.

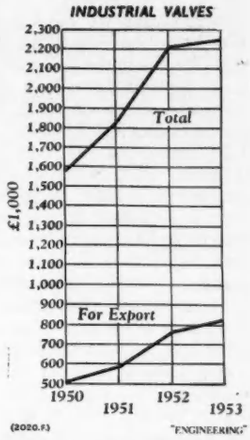
Another industry which has been increasing capacity is the manufacture of ball and roller bearings. The new factory of the Ransome and Marles Bearing Company at Annfield Plain, Co. Durham, opened in September, covers 3·34 acres, and is, therefore, a substantial addition to the industry's production facilities. The demand for bearings is still strong, however, for, though pressure had eased somewhat by the beginning of 1953, manufacturers have been kept occupied by the recovery in the output of motor vehicles.

An example of the extent to which young and expanding British industries have succeeded in raising their productivity is provided by the manufacture of industrial valves. In " A Review of Productivity in the Valve Industry," published by the British Productivity Council, it is stated that an increase in value of the output of 434 per cent., compared with 1946, has been accompanied by a rise of productivity somewhat higher than the average of all industries, which is 2 per cent. per annum. Foundries are highly mechanised and considerable use is made of mechanical handling plant, including compressed-air hoists, conveyors and works trucks. High demand has been stimulated by the growth of petroleum refining and chemical process industries in the United Kingdom, but no engineering industry has a better export record. In 1953, the exports of iron and steel industrial valves alone amounted to £7·7 millions, £1·5 millions more than in 1952. The rate at which the output has been increasing, however, slowed down in 1953, as may be seen from the graph herewith, and since many of the major expansion programmes for the chemical and petroleum-refining industries are now nearing completion, the demand cannot be expected to grow so rapidly in the future.

CONTRACTORS AND CONTRACTORS' PLANT

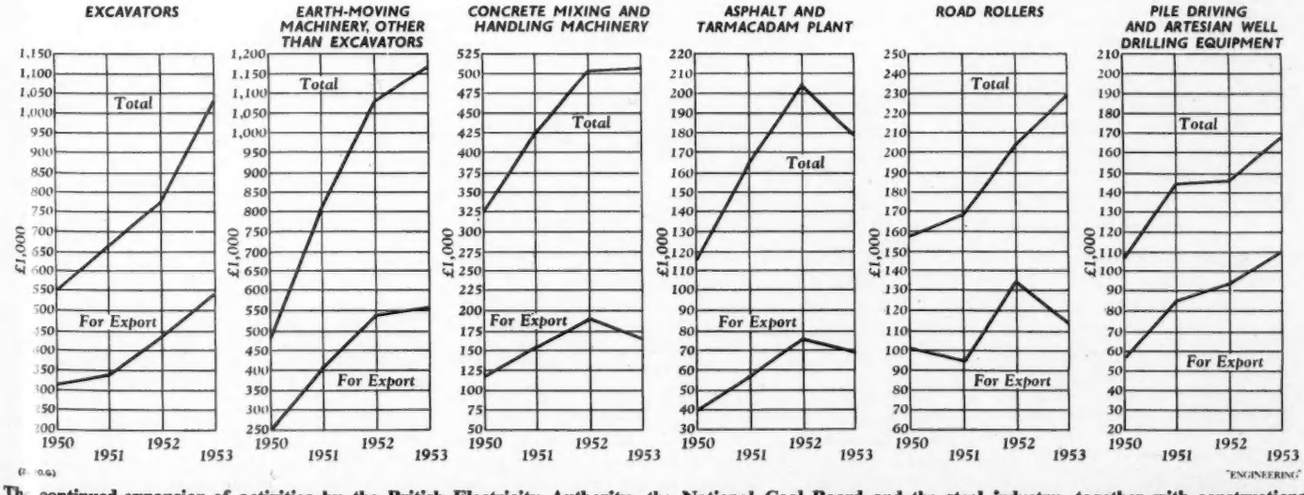
There has been no slackening in the demand for earth-moving equipment and contractors' plant. As may be seen from the six graphs at the foot of this page, the output of all types has increased very considerably since 1950. British manufacturers are still unable to meet fully the requirements of British contractors for heavy-duty equipment, but they have made much progress since the end of the war and have been gaining ground both at home and abroad in competition with American manufacturers, who formerly had a near-monopoly. The plant requirements of British contractors are steadily increasing with the growth of the volume of work on hand. The expansion programmes of the British Electricity Authority and of the steel and coal-mining industries, etc., have all made heavy demands on contractors and constructional engineers, but a significant volume of work is also being carried out abroad.

The major expansion programmes for the chemical industries are now nearing completion and this is reflected in the output of industrial valves. The figures are average monthly outputs.



The difficulties which are being encountered overseas are often considerable, but all are being resolutely tackled. On the one hand, particularly in the Colonies and in under-developed countries generally, there is a tendency to foster local interests by dividing the work in a major project among a large number of small contractors, though it can be carried out economically only by a large contractor with adequate resources. When a large British contractor is asked to tender, he often finds that, because of the large number of competitors who have also been asked to do so and the correspondingly slight chance of receiving the contract, it is not worth while to incur the very large expense of making a survey. On the other hand, British contractors have lost business to the Americans because, individually, they have not had big enough resources.

Steps are now being taken to remedy this deficiency by arranging for the co-operation of several British contractors in certain circumstances. Eight companies, all members of the



The continued expansion of activities by the British Electricity Authority, the National Coal Board and the steel industry, together with constructional work abroad, has encouraged British contractors to buy heavy-duty equipment. The data in the graphs are average values of monthly output since 1950.

Export Group for the Construction Industries, who have been investigating the possibilities of participating in the St. Lawrence Seaway project, have already formed a joint non-operating company, which will act as a central intelligence or co-ordinating bureau. Another company, John Laing and Son, who were originally participants, have withdrawn from the scheme because they have already obtained as much work in Canada as they can handle conveniently. The project for the industrial estate on Annacis Island, British Columbia, on which they are engaged, is scheduled to cost £60 millions. The Treasury policy of increasing British investment in Canada will greatly assist British contractors; it has been announced recently that a number of applications have been sanctioned for direct investment participation in the St. Lawrence Seaway project, and this presumably means that the Government are sanctioning applications from contractors for a supply of Canadian dollars to meet their capital and working costs.

As in the remainder of British industry, the pursuit of higher productivity must continue to be one of the major goals of contractors and constructional engineers. The recent achievement of American executives in completing the Fawley refinery of the Esso Petroleum Company three months before schedule shows that there is still something to be learned from a study of American techniques, especially in the lavish use of mechanical handling equipment, which at Fawley reduced the time spent on the manual handling of materials to 2 per cent. of the total man-hours. British engineers in all industries are, however, unrivalled in the quality of their output, and despite all the marketing difficulties which confront them in 1954, can be expected to make their full contribution to maintaining the prosperity of the United Kingdom.

This article concludes the Engineering Outlook series. Since January 1, each issue has contained an article examining the commercial prospects of the principal branches of the engineering industry. The preceding articles have been: markets and finance on page 10; raw materials, 42; manpower, 73; machine tools, 103; coal mining, 136; locomotives and rolling stock, 170; textile machinery, 202; automobiles, 234; aircraft, 268; shipbuilding, 298; domestic electrical equipment and cables and wires, 331; and agricultural machinery, 362.

ALUMINIUM-ALLOY HEADLESS RIVETS

LOWER UP-SETTING LOADS REQUIRED

By D. A. Barlow, B.SC.

In cold driving aluminium-alloy rivets with a pneumatic gun, the power of the gun which can be used (and hence the size of the rivet which can be closed) is limited by the ability of the operator to handle the equipment without excessive fatigue. In alloys such as B.S.1473/HR13 the driving capacity of the largest guns is limited to $\frac{7}{8}$-in. diameter rivets with the small modified points developed for aluminium alloys, [1,2,3] and $\frac{1}{2}$-in. to $\frac{5}{8}$-in. diameter with conventional rivet points. Although cold squeeze-driving of aluminium-alloy rivets presents no difficulties, any reduction in the up-setting loads would be welcome as it would increase the capacity of existing equipment.

Whitman[4] and also Smith[5] have suggested the use of headless rivets or driven pins, consisting of lengths of rod driven until hole-filling is complete and the shoulders of vestigial points are just beginning to form. If structurally sound, the advantages of such rivets would be considerable: they would be cheaper than normal rivets, and of less weight; more important still, the driving loads would be reduced, thus allowing larger rivets to be driven with existing rivet guns. A further advantage would be that since they require very little ductility of the rod, the strongest aluminium alloys could be used without danger of cracking.

It was found by Whitman[4] that with a normal cold squeeze-driven aluminium-alloy rivet, the springback after driving often caused the rivet point to be proud of the plate by as much as 0·007 in. on a $\frac{1}{2}$-in. diameter rivet (length unstated). Under tensile loading, the point would take no load until the 0·007-in. clearance had been taken up by movement of the plate, by which time the joint would be too loose for many applications. However, with a rivet correctly cold-driven, so that hole-filling was complete, the frictional drag of the plate over the tightly fitting rivet shank was considerable, as much as 33 per cent. of the tensile strength of the rivet shank. This would be sufficient for many purposes; a very small rivet head and point might then be practicable or even no head or point at all. It was therefore considered that a brief investigation of headless rivets would be valuable, and tests on the driving behaviour, shear strength and tensile strength were carried out.

DRIVING TESTS

In driving headless rivets, it is possible to use sufficient length of rod to enable vestigial points to be driven at both ends simultaneously, as shown in Fig. 1(*a*); alternatively, such expansion can be obtained at one end only, the other end of the rod remaining flush with the plate and being backed up by a flat surface in the manner shown in Fig. 1(*b*). This latter method would be very convenient in some cases and would enable rivets to be driven where normal backing up is difficult. Accordingly, both types of rivet were driven in the present series of tests.

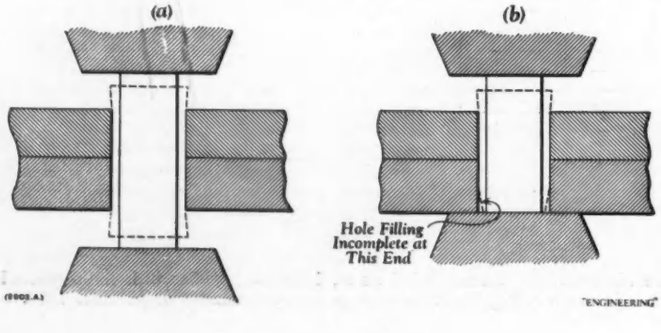


Fig. 1 Aluminium-alloy headless rivets. (*a*) Double-point type, with vestigial points at both ends. (*b*) Single-point type, with point at one end only.

Squeeze-driving tests were carried out on lengths of $\frac{5}{8}$-in. diameter H13T rod inserted in holes in plates, using the compression platens of an Amsler 15-ton universal testing machine to apply the load. The lengths of rod were such as to produce a point height of 0·25 to 0·5 times the rod diameter. Pressure was increased until it could be seen that the ends of the rod standing proud of the plate had expanded so that hole-filling was complete and the shoulders of the points were just beginning to form on the plate, the state illustrated in Fig. 2. The pressure required to drive satisfactory rivets by this means was approximately 30 tons per square inch, compared with 90 tons per square inch for a standard North American cone point, [2,3] the type often used for squeeze-driven aluminium rivets.

In hammer driving, a small pan snap was used for convenience, although driving was stopped, as for squeeze driving, as soon as the shoulders of the projecting part of the rod began to expand beyond the hole diameter. Rod of $\frac{5}{8}$-in. diameter in H13T alloy could be driven in five seconds with a Holman 4X gun (4$\frac{1}{2}$-in. stroke by 1$\frac{1}{8}$-in. bore), compared with about 30 seconds for the small modified points developed for aluminium rivets; $\frac{7}{8}$-in. H13T rod could be similarly driven with a Boyer No. 11 gun (11-in. stroke by 1$\frac{3}{16}$-in. bore), the most powerful available. Further

TABLE I.—*Shear Test Results on $\frac{5}{8}$-in. Diameter H13T Headless Rivets Driven in H15WP Plates*

Double Points		Single Points	
Ref.	Shear Stress Calculated on Rivet Diameter before Driving, Tons per sq. in.	Ref.	Shear Stress Calculated on Rivet Diameter before Driving, Tons per sq. in.
Double-Shear Hammer-driven Rivets. Butt Joints, $\frac{1}{4}$-in. Thick Inner Plates, $\frac{1}{2}$-in. Thick Outer Plates - 2 Rivets in Line			
FGG 1	11·1	FGG 9	11·0
2	10·8	10	10·85
3	10·75	11	10·95
4	11·1	12	11·0
5	11·15	13	10·85
6	10·85	14	11·2
7	10·95	15	10·65
8	11·15	16	11·0
Mean	11·0	Mean	10·95
Double-Shear Squeeze-driven Rivets. Butt Joints as Above			
FGH 1	10·9	FGH 9	10·7
2	11·2	10	10·55
3	11·15	11	10·5
4	10·9	12	10·7
5	11·4	13	10·5
6	11·3	14	10·7
7	11·25	15	10·6
		16	10·55
Mean	11·15	Mean	10·6
Single-Shear Squeeze-driven Rivets. Single-lap Joints, $\frac{1}{4}$-in. Thick H15WP Plates			
FGJ 1	11·9	FGJ 10	9·6
2	11·6	11	9·4
3	11·45	12	9·3
4	11·45	13	9·5
5	11·6	14	9·1
6	11·4	15	9·3
7	11·7	16	9·3
8	11·7	17	9·25
Mean	11·6	Mean	9·35

TABLE II.—*Control (Double-Shear) Tests on Rod*

Reference	Shear Stress, Tons per sq. in.
DME 1	11·6
2	11·5
3	11·25
4	11·45
5	11·5
6	11·1
7	11·2
Mean	11·35

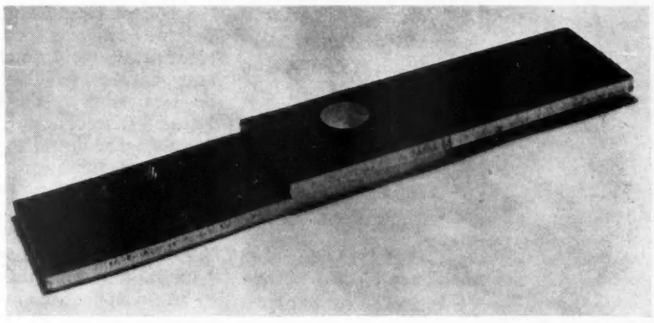


Fig. 2 A typical headless rivet made of $\frac{5}{8}$-in. diameter rod of H13T alloy, squeeze-driven in a simple lap joint.

tests showed that at the maximum capacity of the No. 11 gun, H15WP rod 1 in. in diameter could be driven, compared with only $\frac{7}{8}$-in. diameter rivets in H13T (a much softer material) with the small modified points developed for hammer driving.

Sectioned joints showed that in hammer-driving headless rivets, unlike squeeze-driving, complete hole-filling was only obtained if the hole clearance was small, as might be expected. A section of a 1-in. diameter H15WP rivet driven in a 2-in. thickness of plates is shown in Fig. 3; the hole clearance was 0·005 in. and hole-filling is complete. At clearances above 0·010 in. incomplete hole-filling occurred in all except very small thicknesses of plate, even with smaller diameter softer rivets. In contrast to this, when driving the small modified points, hole-filling is obtained with clearances between $\frac{1}{64}$ and $\frac{1}{32}$ in. It is evident, therefore, that in gun-driving normal rivets (unlike squeeze-driving), hole-filling continues as the point is being formed. The small clearances necessary in gun-driving headless rivets would require reaming of the holes; in squeeze-driving, on the other hand, clearances are less important.

SHEAR TESTS

Double-shear specimens consisted of butt joints with centre plates of $\frac{1}{2}$-in. thick H15WP plate and outer plates of $\frac{1}{4}$-in. thick H15WP, each joint being fastened with two $\frac{5}{8}$-in. diameter H13T rivets. Both squeeze-driven rivets were tested with both "single" and "double" points.

Single-shear test pieces consisted of single lap joints in $\frac{1}{4}$-in. thick H15WP plate joined by one rivet in $\frac{5}{8}$-in. diameter H13T. The tensile stress always present in rivets stressed in single shear is greatest with the thinnest plates, since bending is most severe. A diameter/thickness ratio of 2·5 was therefore chosen to give the greatest tensile stressing of the rivets likely to be met with in practice in single-shear joints.

The results in Table I show that for both types of rivet the nominal shear stresses in double shear were very slightly below that of the rod given in Table II. The shear stress on the rod was measured in a "pin shear" box (that is, with stresses similar to those applied to the rivets) but with the rod projecting considerably at both ends and with no separation of the plates being allowed. Shear stresses on the rivets were calculated on the original rod diameter, as the hole clearance used was very small, being less than 0·005 in. in all cases. It was noticed that, in shearing of rivets in which one end was flush with the plate, this flush end was partly pulled through the plate. The vestigial points also allowed a slight "pulling in" of the rivet shanks, so that, as the fracture surfaces showed, bending of the rivets had taken place; a normal point would obviate or greatly reduce this bending by preventing the pulling in of the shanks and the separation of the plates.

In single shear, when points were driven at both ends, the shear stress was slightly greater than that of the rod in double shear; this was to be expected, as the strength of a material in single shear is normally slightly greater than that in double shear. With one end flush, a drop of 20 per cent. in shear strength was obtained. The rivet end which was flush with the plate was partly pulled through the plate to a greater extent than was experienced in double shear tests. A pulled rivet in a single-lap joint after a shear test is shown in Fig. 4.

No load-deflection curves were obtained but from observation of the behaviour of the rivets in the above tests it is fairly certain that joints with headless rivets have lower proof loads than joints with normal rivets. However, this may not be a disadvantage as the low proof load will help to reduce stress concentrations in many types of structure; moreover, the low proof loads would be of little disadvantage when designing on plastic theory.

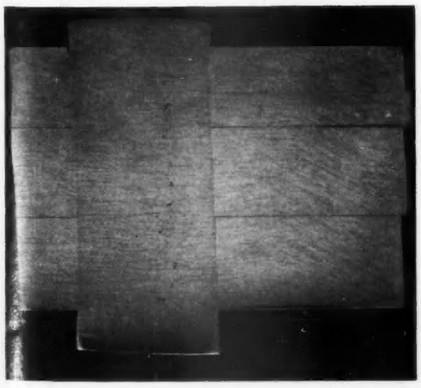


Fig. 3 A section through a riveted joint, demonstrating the complete filling of the hole. The headless rivet is of 1-in. diameter H15WP rod, gun-driven in 2 in. of plate; the hole clearance was 0·005 in.

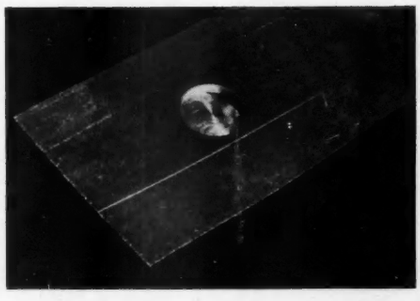


Fig. 4 Plate and rivet from a single lap joint, tested in shear, showing the rivet "pulled through" the plate. The rivet was of $\frac{5}{8}$-in. diameter H13T rod, driven through $\frac{1}{4}$-in. H15WP plate; the face end of the rivet was flush with the plate and the point was driven at the other end.

TENSILE TESTS

A number of tensile tests were carried out on $\frac{7}{8}$-in. diameter H13T headless rivets, squeeze-driven in 4$\frac{1}{2}$-in. by 3-in. by 1$\frac{1}{2}$-in. steel plate; each pair of plates contained one rivet which was tested in tension by pulling the plates apart. The results are given in Table III and show that, when swelling is allowed at both ends of the rod, the strength is high, though variable. The variation was due to the varying point heights, but there is no reason why tensile strengths of over 50 per cent. of that of the shank should not be consistently obtained if the point height is sufficient, say 0·4 of the shank diameter. (The actual length of rod used is not, of course, critical.) With one end flush, the strength was much lower and examination showed, as would be expected, that hole-filling at the flush end was incomplete, giving low results.

TABLE III.—*Tensile Tests on $\frac{7}{8}$-in. Diameter H13T Headless Rivets*

Tensile stress on original-rod diameter, tons per sq. in.

Double Points	Single Points
8·6	0·7
8·7	0·2
7·6	1·4
14·3	0·4
6·85	0·5
12·5	0·3

Ultimate Tensile Stress of rod = 18·0 tons per sq. in.

There are various applications in which headless rivets might not be desirable, even if tensile stressing is avoided. It is not known, for example, whether headless rivets would produce water-tight joints. Further, there is no knowledge of the behaviour of headless rivets in fatigue, although for many structural applications, fatigue loads are small.

In driving headless rivets, the plates must be maintained in a central position in relation to the length of rod, so that points may be formed at both ends. This would not be difficult to arrange in squeeze-driving, but it would be more difficult in hammer-driving.

In these tests, flat vestigial points were driven for simplicity and convenience. There is no reason, however, why suitably shaped snaps should not be used to give a rounded or bevelled edge to the points so as to improve their appearance.

CONCLUSIONS

(1) When suitably driven, headless rivets have adequate strength under most conditions.

(2) They can be squeeze-driven at much lower loads than normal rivets.

(3) They can be hammer-driven in larger sizes than rivets with either normal or modified points, but very small hole clearances are essential.

(4) In driving, vestigial points should be formed at both ends, since if one end is kept flush with the plate the joints will have negligible tensile strength due to incomplete hole-filling.

(5) They are cheaper and lighter than normal rivets.

(6) Even the most brittle alloys can be used without danger of cracking.

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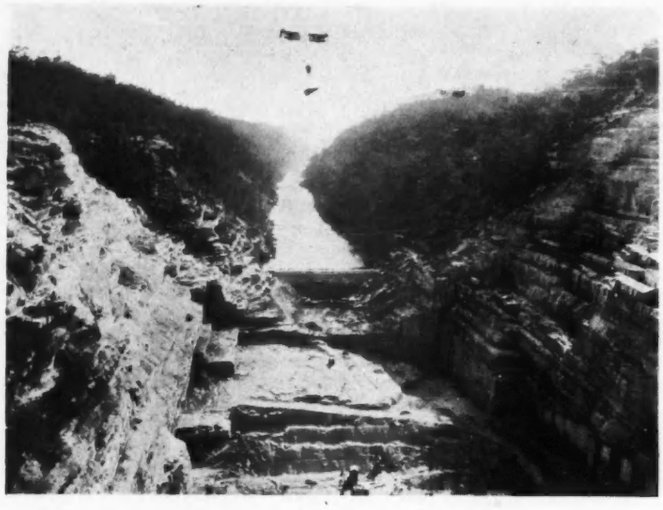


Fig. 1 The Warragamba Gorge, New South Wales. A deep narrow gorge, nearly straight and 14 miles long with steep sandstone walls, it is an almost ideal site for a dam and the formation of a reservoir. The dam will tap a catchment area of 3,800 square miles causing the river to back up for 35 miles.

THE WARRAGAMBA DAM

PLACING CONCRETE IN HIGH AMBIENT TEMPERATURES

A new mass-concrete dam, the Warragamba, now being constructed 50 miles west of Sydney, New South Wales, will be the largest in Australia, impounding 460,000 million gallons of water. The 420-ft. high wall will be the highest in Australia. The cost of building the dam, which involves bringing all the gravel required 12½ miles across country by aerial ropeway and the installation of a refrigeration plant to keep the temperature of the concrete down to 55 deg. F., is expected to be £A23,250,000. Completion of the dam, planned for 1957, will ensure an adequate water supply for Sydney and the surrounding countryside until at least the end of this century.

The population of Sydney is approaching 2,000,000, but the city's Metropolitan Water Board actually supplies water to more than twice that number, for it has to service both the outlying areas and a coastal belt extending as far as Port Kembla, a steel town 50 miles to the south. With the continuing development of industry in the area and increasing consumption *per capita*, the Board's existing six reservoirs hold only sufficient water to meet immediate needs so long as a drought does not intervene. Present consumption averages 151 million gallons per day, but the peak demand for 24 hours has reached 255 million gallons.

IDEAL LOCATION FOR RESERVOIR

The new dam is situated in the Warragamba Gorge in the foothills of the Blue Mountains - a site described as being ideal for the large-scale storage of water. Narrow and almost straight for 14 miles, it has sheer sandstone walls rising to between 400 and 500 ft. The river, which cuts directly through the mountain range, is a tributary of the Nepean River which feeds the seaward-flowing Hawkesbury; it taps a catchment area of over 3,800 square miles and the new dam will cause the river to back up for 35 miles thereby creating a long deep narrow lake in rough, heavily timbered and mostly useless country, though a section of the fertile Burragorang Valley will also be flooded. A view looking upstream from the site of the dam is shown in Fig. 1.

Preliminary work was begun in 1946. The project is an extension of an emergency system set up in the early stages of the last war to off-set a severe water shortage brought about by an eight-year drought. In 1940, a 50-ft. weir impounding 580 million gallons was built near the present site. The water held behind this weir was originally pumped through a 48-inch pipe-line to the Prospect Reservoir, 16 miles away, but the original line has now been replaced by a larger pipe, the first section across the Nepean River having a diameter of 106 in. A second pipe-line will be laid subsequently, both lines passing through a tunnel two miles long leading from the site of the dam. These two sections will feed into three 84-in. pipes, only one of which has as yet been completed.

The dam will be of the straight gravity type, 1,100 ft. long at the crest; the maximum depth of water impounded will be 340 ft., but the deepest foundation for the cut-off gives the dam an overall height of 420 ft. The width of the spillway on the downstream face will be 300 ft., while top drum gates, 40 ft. high, will be opened in time of full flood. In all, the dam will contain 1·4 million cub. yd. of concrete and about 2·5 million tons of gravel and sand, which will have to be brought to the site from the nearest pits 12½ miles away on the Nepean River. To do this, the aerial ropeway shown in Fig. 2 has been erected across the intervening countryside.

AERIAL ROPEWAY 12½ MILES LONG

The aggregate for the concrete of the dam is being obtained from McCann's Island, near the town of Penrith on the Nepean River. An island only in time of flood, it is really part of the river bank, and a 100-acre deposit of gravel is being worked by a 160-ton excavator. The excavator, which is Diesel driven, is a Ruston Bucyrus 5W fitted with a 120-ft. boom. The excavated spoil is taken from the pit in 20-ton rock dumpers to a processing plant situated nearby, where it is crushed if need be, graded and put into stock-piles by the plant shown in Fig. 3.

From the stock-piles the aggregate is loaded mechanically into the ropeway buckets. Vibratory feeders are used to discharge the material into four measuring hoppers from whence it is poured into the buckets. The buckets coast into the loading station on a steel rail until a chain-haulage grip takes over, drawing it towards the hopper where loading is completed in about six seconds. At the construction site, the buckets are handled automatically by a trip device which overturns each bucket, so unloading its contents into the graded-aggregate bins near to the concrete-mixing plant. To ensure safe operation of the ropeway, control is vested in one man located at a master control board; all other operators report to the controller by telephone.

The ropeway is of a bi-cable type with outgoing

Fig. 2 The gravel and sand for the Warragamba dam are being taken from the pits to the site, 12½ miles away, by aerial ropeway. The capacity of each bucket is 27 cwt.

Fig. 3 The plant at the gravel pits is highly mechanised and all the gravel is graded in stock-piles before being transported to the site of the dam.

and returning wire ropes set on the top of steel standards. The buckets, which have a payload of 27½ cwt., are suspended from wheeled carriers which run along the ropeway, a separate hauling rope being attached to the carriers below the wheels. All told, there are 195 standards supporting the cableway, on an average 334 ft. apart and ranging between 13 ft. and 120 ft. high. At one point – the longest single span between standards – the ropeway spans 1,080 ft. over the Nepean River.

There are 550 buckets in use on the ropeway, moving at about half-minute intervals and bringing up to 170 tons of aggregate an hour to the dam. Built by a firm of South Australian contractors, the Perry Engineering Company, Adelaide, the aerial ropeway was completed at the end of 1953 at a cost of £A500,000. In spite of its cost the ropeway is proving to be efficient and cheap by comparison with other methods.

At the site, corrugated steel silos have been erected for the storage of cement, together with a central mixing plant and a 100-ft. tower which houses the ice-making plant shown in Fig. 4. Two heavy-duty travelling cableways and a 1,000-ft. suspension bridge span the site for taking men and materials to work in progress. It is planned to place concrete at the rate of 2,000 cub. yd. per day, the cableways having capacities of 18 tons and 10 tons respectively to meet this demand. In addition to normal sized aggregate, "plums" up to 6 in. in diameter will be permitted.

COOLING PIPES IN CONCRETE

It is intended that the dam wall shall have a constant temperature of 55 deg. F., in spite of the heat of hydration and the location of the dam in an area where exceptionally high summer temperatures prevail, in an effort to minimise the expansion and contraction in the finished concrete and so reduce the number of cracks which might develop. The dam is being built as a series of independent blocks with transverse and longitudinal joints spaced 50 ft. apart. Cooling pipes are being embedded in the concrete and chilled water from the refrigeration plant will be circulated through them for some months after setting. Ultimately the pipes will be filled with cement grout under pressure. To reduce the initial temperature of the concrete, cooling of the aggregate and mixing water to just above freezing temperature is also being employed.

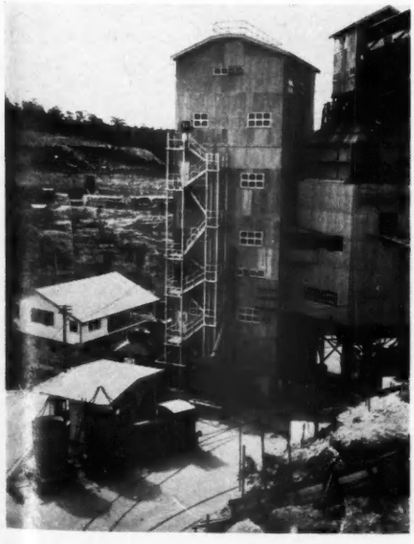


Fig. 4 The ice-making plant and central concrete batch mixer. To minimise temperature effects the concrete is being mixed cold and chilled water pumped through pipes embedded in the mass of the dam.

The ice-making plant, the first of its kind to be used in Australia, is housed in a framed structure of prestressed concrete. The 12 principal supporting members of the tower, all cast on the ground and erected later, are nearly 76 ft. long and have a cross-section of 18 in. square.

The completed dam will be provided finally with hydro-electric plant to meet future demands for more power in New South Wales. It is not intended, however, to instal the generators yet, the first function of the reservoir being to ensure the water supply for Sydney and the surrounding countryside.

The period that will elapse before the reservoir is filled is a matter for conjecture. Records show that, had the dam been completed at the time of exceptional flood in 1952, the reservoir would have been filled in five days. In periods of drought, such as occurred just prior to the war, it could have taken as long as eight years. Nevertheless, when it is filled, the daily water requirement of Sydney is expected to be secure for at least two generations to come.

* * *

A NEW FIRE-FIGHTING CHEMICAL

Exceptional Powers

A new type of pressure-operated fire extinguisher in which the halogenated hydrocarbon, chlorobromomethane (CH_2ClBr), a new fire-fighting chemical, is held with absorbed carbon dioxide under constant pressure, is now marketed by Nu-Swift Limited, Elland, Yorkshire.

Tests carried out on a petrol fire contained in a metal tray, 2 sq. ft. in surface area and 4 in. deep, have shown that an old-fashioned quart-size Nu-Swift hand pump holding carbon tetrachloride failed to extinguish the fire after pumping for 40 seconds. On the other hand, a pressure-operated chlorobromomethane (or CBM) extinguisher of identical size put out a similar fire in 1½ seconds.

The explanation of this extraordinary increase in fire-fighting power lies in the low inhibitory factor of CBM compared with that of other chemicals employed in extinguishers. Another important factor is the thorough atomisation of the hydrocarbon by the carbon dioxide. It may be noted that the inhibitory factor represents the least quantity of gas with which the surrounding air must be diluted in order to extinguish flames and prevent combustion. The lower the inhibitory factor, the more effective is the gas or vapour in the task of extinguishing fire. Under standard conditions using highly inflammable n-hexane, the inhibitory factor of carbon dioxide is 22 per cent., carbon tetrachloride 10 per cent., methyl bromide 7·2 per cent., and chlorobromomethane 6·2 per cent.

The new extinguishers containing CBM are less than 16 in. in height and are marketed under the registered trade name of "Chloro-Flash." They are recommended for highly hazardous risks such as may occur with electrical or radar equipment, neon signs, television installations, switchgear, or as the result of spilling inflammable solvents in laboratories and garages.

The extinguisher is particularly suitable for use in the tropics and remains effective at arctic temperatures as CBM freezes only at − 120 deg. F. (− 86 deg. C.). The liquid, it is pointed out, is no more toxic than carbon tetrachloride and is a non-conductor of electricity. It has been tested and found safe on electrical circuits of up to 66,000 volts.

LOW WEIGHT PER HORSE-POWER

Progress in Engine Design

In a discourse before the Royal Institution entitled "The Search for Lightness," on Friday, March 12, Mr. Hayne Constant, director of the National Gas Turbine Establishment, surveyed generally the problems and progress of engine design from the point of view of low weight-to-power ratio. Lightness was necessary, particularly for aircraft, he said, for economy in fuel and in materials. The first task of the designer was to ensure that his machine was not inherently heavy—for example, in a locomotive all the weight should be on the driving wheels. Secondly, the thermodynamic cycle must not be inherently heavy; the steam engine, with heat exchangers, was unavoidably heavy. Thirdly, a reciprocating mechanism must be avoided since it produced energy only intermittently. These considerations led to the gas turbine as the lightest form of prime mover. The weight per horse-power of a turbine decreased as engine diameter was decreased down to about 20 in.; below that, viscosity effects reversed the trend.

In providing adequate strength, the designer had to decide whether the turbine blades were likely to fail under steady stress, under vibratory stress, or by creep. The vibratory stresses could not be calculated. The final step to attaining lightness was by genius in detail design, and in eliminating superfluous details as the machine developed.

Mr. Constant then reviewed the trend in weight per horse-power for various machines over the past 100 years or so, showing that, in general, the curve of specific weight against time fell steeply at first and then tended to flatten. For bicycles the specific weight had fallen from over 60 lb. per horse-power in 1860 to a little over 20 lb. per horse-power in 1954; for locomotives, from 500 lb. per horse-power in 1832 to under 80 lb. per horse-power in 1954. There was a limit for locomotives of 60 lb. per horse-power – below this wheel spin would occur. The curve for naval engines was interesting, because it showed how the introduction of triple-expansion in the 'eighties, the steam turbine in 1900, and oil fuel just before the first World War, accelerated the downward trend. To-day, with the introduction of the gas turbine, the naval engine was at the beginning of another period of rapid development.

The progress of the aero piston engine had been very rapid. The Wright brothers' engine at 12 lb. per horse-power was heavy; 4 or 5 lb. per horse-power was a typical value for that period. By 1940, the specific weight had fallen to just over 1 lb. and the curve was becoming flat. The evidence of the flattening-out led to work in the 1930's on the possibility of aero steam turbines, but it was soon realised that steam turbines were inherently heavy. The gas turbine driving a propeller was introduced in 1945; in ten years of development its specific weight had fallen from 1·8 to 0·6 lb. per horse-power. The centrifugal jet engine, introduced in 1941, had a specific weight of about 0·7 lb. per horse-power. This was followed about five years ago by the axial-flow jet engine, at about 0·45 lb. per horse-power; to-day, the axial-flow engine had a specific weight of 0·26 lb. per horse-power.

In conclusion, Mr. Constant said that it was not possible to predict the future by consideration of the past. It was interesting to speculate on whether future ocean liners would rise on hydrofoils and skim the Atlantic at 60 knots, and whether motor cars, weighing no more than the motor bicycle to-day, would sprout rotating wings and take to the air as helicopters.

THE DOMAIN OF THE HELICOPTER

In this article are presented the views of an eminent helicopter designer on the scope and economic possibilities of various types of helicopter, including a project for a "convertible" machine which takes off and lands as a helicopter and transforms itself into a fixed-wing aircraft during cruising flight. It is extracted from the Seventh Louis Blériot Lecture entitled "The Domain of the Helicopter," which was given in Paris on March 10, by Mr. Raoul Hafner of the Bristol Aeroplane Company, Limited. His survey embraced a wider field than is possible to indicate here, covering also the historical development of the helicopter against the background of aeronautical activities as a whole and reviewing the fundamentals of the rotating wing, its performance and limitations, together with methods of rotor control, power supply, transmission fundamentals, and the basic differences between various rotor configurations.

TRANSMISSION OF POWER

The predominant hazard of the fixed wing lies in its high minimum flying speed which, combined with bad visibility or a power failure, is liable to lead to serious consequences. The hazard in the helicopter, on the other hand, is the mechanical complexity of the rotor system. Like a chain, if one link fails, the whole fails. Therefore, everything else being equal, the fewer rotors and blades there are in a rotor system, the greater is its safety.

Power transmission may range from the orthodox mechanical transmission to "gas shafts," between, on the one hand, a gas generator and a jet in the tip of a rotor blade, or on the other hand, a gas turbine converting the gas power into shaft power. Mechanical transmission will stay with the helicopter for some time to come, simply because it is, for all but the largest rotors, the lightest and most efficient form by which power can be supplied in the form needed at the rotor.

The tip-driven rotor is torque-balanced within itself and only rotor thrust is transmitted to the aircraft body. It is the only practical form of single rotor helicopter, but in respect of centre-of-gravity travel, it is necessarily rather limited. The tip-driven rotor has, nevertheless, a marked advantage on the score of weight and mechanical simplicity. A single-rotor helicopter can achieve a moderate degree of stability – at least in forward flight – if the fuselage is suitably shaped and horizontal and vertical surfaces are fitted at the tail.

Just as tip drive is natural to the single-rotor helicopter, so mechanical drive is natural to the multi-rotor helicopter. Other than torque-balanced or twin-rotors, only one form of multiple rotor has come into prominence. It consists of one large rotor supporting the whole weight of the aircraft, and a small rotor aft of the main rotor, producing a relatively small lateral thrust which, in conjunction with a large lever arm, balances the main rotor torque. A small change in any of the forces or moments, such as is caused by normal disturbances in flight, requires adjustment almost all round and, as a result, this type of helicopter is more difficult to fly, both for human and automatic pilots, than are the symmetrical forms of aircraft.

The necessarily different speeds of the unequal rotors produce a wider band of excitation frequencies than applies with either a single rotor or equal rotors, and this increases the difficulties of avoiding resonant conditions. On the score of rotor weight there is also a penalty, because two rotors of different size weigh more than two equal rotors capable of carrying the same weight. As regards safety, the arrangement is probaby slightly better than twin rotor configurations, because experience has shown that a failure of the tail rotor or its transmission branch does not necessarily lead to fatal consequences.

Torque-balanced twin rotors are generally identical in lift, diameter and speed but they rotate in opposite directions. We distinguish between "eclipsed" and "non-eclipsed" rotors. Eclipsed rotors are either concentric or closely intermeshing. Compared with the single-rotor helicopter they offer the structural expense of two rotors, with no material aerodynamic gain and, in particular, no gain in effective rotor disc area. There is also the danger of blade fouling in gusty conditions. Nevertheless, they permit a more compact transmission system than do the other two-rotor configurations, the side-by-side and the arrangement in tandem.

The tandem arrangement permits a considerable centre-of-gravity travel along the "axis of suspension" connecting the two rotor hubs without seriously upsetting the balance of the aircraft, a major advantage over the side-by-side configuration, particularly as it can be arranged that the "axis of suspension" runs with the major axis of the fuselage.

Fig. 1 Bristol 173 helicopter with stub wings.

While the aerodynamic performance in hovering is the same, there is a significant difference in forward flight between the side-by-side and the tandem configuration. The former has a large "wing span" over the two rotors and consequently its induced losses are relatively low, whereas the latter, with only half the span of the former, has a higher induced flow. Against this, allowance must be made for the considerable weight and the parasitic drag of the lateral outrigger structure which side-by-side rotors require, whereas in the tandem arrangement the rotor supports are light and have negligible drag. The increased complexity and the consequently reduced safety standard of configurations involving more than two rotors are not acceptable. They can offer no material advantages over the two-rotor configurations.

The pure helicopter relies wholly on its rotors for sustentation as well as propulsion. The speed envelope of the pure helicopter is controlled mainly by (*a*) the design of the blade tip and (*b*) the blade loading, and speed increases beyond certain limits are bought at progressive expense in power.

THE COMPOUND HELICOPTER

The most effective means of compounding the rotor with other aerodynamic devices in order to advance the performance of the helicopter is the stub wing (Fig. 1). Such a wing has no effect when hovering or during slow-speed flight, but as speed is gained it progressively supplements the rotor thrust until, at a given maximum speed, a worth-while percentage of the all-up

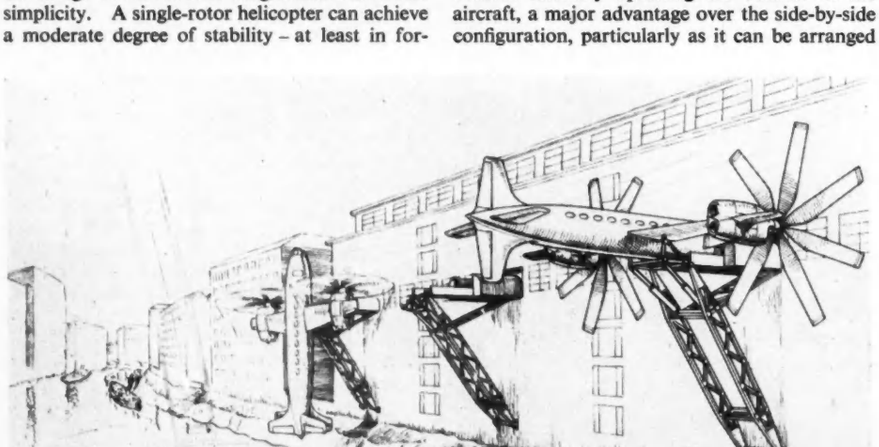


Fig. 2.

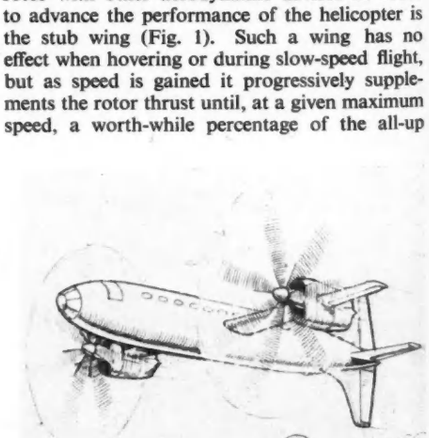


Fig. 3.

Figs. 2 and 3 Convertible helicopter project. The machine takes off as a helicopter, with fuselage vertical, from gantries. During cruising flight it gradually assumes a horizontal attitude as lift is transferred from the rotors to the fixed wing surfaces. In the cruising configuration the rotors act as propellers. The passengers are seated in rotatable seats so that at all times they remain seated vertically.

weight is taken by the wing, the rotor being correspondingly unloaded. Thus the speed of the helicopter is increased without change either in the rotor blade area or rotor power. The rotor coning angle is also reduced and this diminishes vibration; alternatively it will permit a reduction in blade weight.

On the other hand, if no speed increase is desired, the stub wing can be used to enhance the economy of the helicopter, as it then permits an increase of the blade loading without ill effects, but with the advantage of a reduction in power. Allowing for the drag and the weight of the fixed wing, there is a net gain, because the fixed wing is more efficient in the production of lift at speed than is the rotating wing. By mounting the undercarriage on the wing a considerable weight-saving is achieved.

There are, nevertheless, certain limits which must be observed in the unloading of the rotor. The helicopter is basically controlled in flight through its rotor, or rotors, and a loss in rotor thrust means a loss in some of its control. If, therefore, the rotor unloading assumes considerable proportions, it is necessary for the rotor control to be supplemented by a wing control.

In addition, there is the problem of propulsion. In a pure helicopter sustentation and propulsion are obtained together by a small forward tilt of the rotor vector. Compounding the rotor with a stub wing will, however, decrease the rotor lift while at the same time increasing the aircraft drag. This means that the rotor thrust vector must be given a considerable forward inclination which, at a certain stage, begins to introduce aerodynamic complications. These difficulties may to some extent be delayed by additional compounding with a propeller or with a turbojet.

THE CONVERTIBLE HELICOPTER

The convertible helicopter is a helicopter capable of conversion during flight so that the total lift is substantially transferred from the rotating wings to other wings, and vice versa. It is not possible to arrive at a practical appreciation of the possibility of a convertible helicopter without making a relatively detailed study both of its design and its operation.

Briefly, then, it may be stated that the convertible helicopter is potentially capable of establishing itself in a certain sector of the air transportation field, provided the technical problems of conversion can be solved in a simple and practical manner. One of the most promising forms (Fig. 3) comprises a more or less standard aeroplane body, a pair of relatively small fixed wings designed to give optimum performance at cruising flight, engines mounted near the wing tips and driving two rotors but, as well, interconnected to form one transmission system as in conventional helicopters. The rotors sustain the weight of the aircraft in the hovering condition of flight when the longitudinal axis of the aircraft is vertical, and act as propellers in the cruising condition of flight when this axis is horizontal; thus the aircraft as a whole, rather than one part of it, is rotated.

The conversion from one extreme flight condition to the other is slow, or quasi-static. Thus, when converting from the hovering condition the aircraft axis is at first slightly inclined in the normal plane of the aircraft, which causes a horizontal component of the rotor thrust. This gradually accelerates the aircraft horizontally, and the attainment of a small horizontal velocity, together with the induced velocity, results in an airflow which produces a small normal force on the wing in a direction opposite to the motion, that is to say, a small vertical component is introduced. A further tilt of the aircraft increases the horizontal velocity and causes a greater force on the wing so increasing the vertical component. This force grows until the reaction on the wing is vertical and equal to the aircraft weight. The aircraft will then fly at high speed and with its axis in the direction of flight. The conversion back to helicopter flight is the reverse of this process.

It can be shown that in order to avoid stalling the wing during the conversion, the disc-loading must be high and the rotor diameters are consequently small. For this reason the power-required curve of this convertible is much higher at the hovering point than that of the conventional helicopter, whereas elsewhere both curves are similar. In order to meet this power characteristic, the power installation of such a convertible is preferably comprised of free-turbine power units – one pair on each side and of such power that, if necessary, any three units can sustain the aircraft during hovering (for safety). For normal cruising flight only two engines need be used (at their optimum cruising power), which naturally ensures a low fuel consumption. The aircraft is provided with two pockets in its wings fitted approximately in the position usually occupied by the conventional undercarriage. These pockets represent strong points capable of carrying the weight of the aircraft. Rotor control is used both during hovering and cruising flight, but is supplemented by certain fixed-wing controls. In cruising flight the pilots lie in a prone position, whereas during hovering they stand upright, the cockpit (situated in the nose of the aircraft) being in this condition somewhat akin to a circular bridge of a ship. The passengers are seated in rotatable seats which automatically maintain a level attitude during the process of conversion.

LANDING ON GANTRIES

Landing (Fig. 2) is made by means of a specially designed gantry in the following manner. The landing gantry comprises fittings, not unlike the terminal buffers in railway stations, which contain shock absorbers, that can yield in all directions, and which fit the pockets in the wings of the aircraft. The helicopter approaches the gantry in the hovering attitude until it comes to within about 50 yards of it. A steel cable is then lowered from a specially designed power winch, fitted at the centre of gravity of the aircraft, and which is under the control of the pilot. The end of the steel cable is then attached to an anchor point on the gantry. The pilot thereafter continues to hover the aircraft which is then winched in towards the gantry until the spring buffers register in the pockets of the aircraft.

The aircraft having been safely secured to the gantry, its engines are stopped and it is then rotated by a small ram into the horizontal position, after which unloading can commence (Fig. 2). The converse procedure applies to the take-off. The pockets on the aircraft and the landing buffers of the gantry should be standardised – like the gauge of the railways – in order to permit interchangeability of various makes of helicopters. A number of such gantries are provided in a rotor station, permitting the simultaneous operation of a number of helicopters.

In the event of two or more engines failing together, an emergency landing in aeroplane fashion could be made with the convertible on an ordinary runway, in which case the rotors would suffer severe damage.

There remains the question of comfort. The rotation of the aircraft during take-off and landing may be considered an unpleasant or even frightening experience for passengers. It should be born in mind that there is nothing physically unpleasant in this experience. Linear and angular accelerations are almost nil and certainly less than those in a conventional take-off. The experience is in fact only visual. The writer believes therefore that there can be only psychological reasons for discomfort, and these will disappear with increasing familiarity of a new mode of transportation. There is virtually no vibration in forward flight, and in hovering only during conversion. This aircraft with its large low-speed rotors (or propellers) and turbines is fundamentally less noisy than any other known aircraft.

ECONOMIC COMPARISON

In an attempt to relate a number of typical

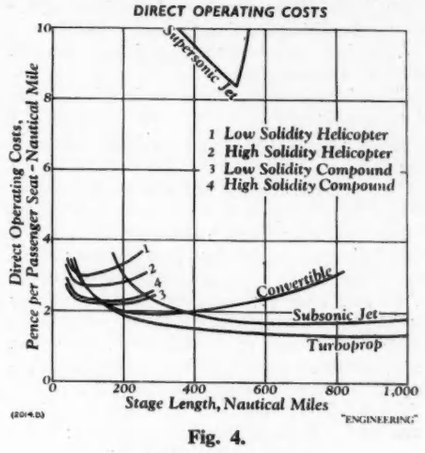


Fig. 4.

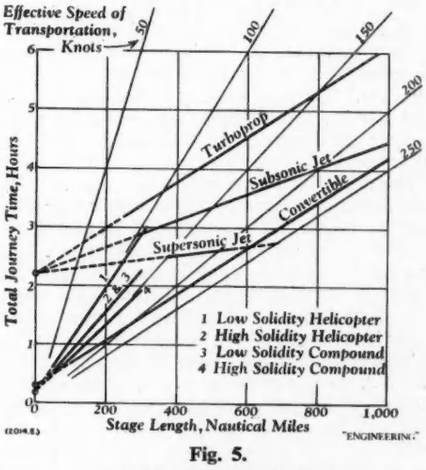


Fig. 5.

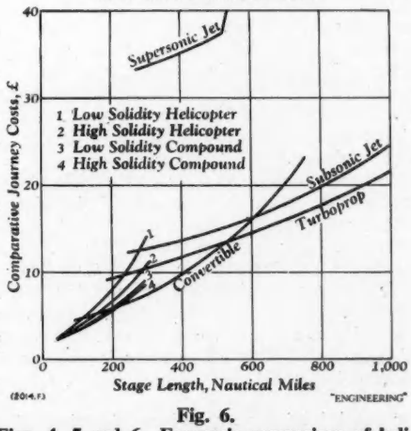


Fig. 6.

Figs. 4, 5 and 6 Economic comparison of helicopters and other transport aircraft. The convertible helicopter shows to best advantage between stage lengths of 200 and 530 miles.

examples of air transport, eight types of aircraft have been selected for economic comparison, such that between them they cover at least a major part of the civil air transporation field.

In the order of their cruising speeds they are:

(1) A pure helicopter, designed for best economy at low cruising speed.

(2) A pure helicopter, designed for best economy at moderate cruising speed.

(3) A compound helicopter, designed for the same cruising speed as (2).

(4) A compound helicopter, designed for higher cruising speed.

(5) A convertible helicopter, designed for best economy at high cruising speed.

(6) A propeller-driven aeroplane, designed for the same cruising speed as (5).

(7) A jet-driven aeroplane, designed to cruise at high subsonic speed.

(8) A jet-driven aeroplane, designed to cruise at supersonic speed.

The helicopters are assumedto operate between city centres.

The optimum weights of these aircraft spread over a wide range and would follow approximately the order given. At the one extreme, a pure helicopter, suited for operation over ultra-short stage lengths, would have an all-up weight of about 30,000 lb.; intermediately a propeller or jet driven aeroplane for 2,000 miles stage length would weigh about 100,000 lb. and at the other extreme a supersonic long-range aeroplane appears to be still too small at 200,000 lb.

The costs* of the eight different operations have been computed under two headings:

(*a*) Direct operating costs of the aircraft.

(*b*) The airline costs including overheads.

It will be seen that in terms of direct operating costs (Fig. 4) the subsonic jet and the turboprop aeroplane are without competition on long journeys. They are both, however, and especially the jet, less efficient in short-haul work, because of the reduced block speeds in this regime of operation.

Here the helicopter makes its claim. The superiority of the compound helicopter over the pure helicopter will be noted, this being mainly due to the higher speed of the compound. It is evident that area vested in the fixed wing is better than area in the rotating wing. The convertible helicopter lies half-way between the other helicopters and the subsonic aeroplanes.

The supersonic aeroplane, cruising at about Mach 2, is quite uneconomic. This aircraft has suffered in this comparison because it is so much removed from its optimum size. There are indications that with increase in all-up weight its curve will move downward and slightly to the right, but even then it does not appear to be an economic proposition. Really high speeds can probably be achieved economically only outside the earth's atmospheric envelope, and the true rocket vehicle may, therefore, be the most practicable form of high speed aircraft. The airline costs (not reproduced here) present a similar picture.

A most revealing graph is that showing total journey time (Fig. 5) from which it is evident that, for short-haul journeys, the slow helicopters are much faster than the fast aeroplanes. The turboprop and the subsonic jet aeroplane are in their element for journeys from 1,000 miles upwards. The supersonic aeroplane reaches its best effective speed of transportation at a range of about 600 miles when, however, it runs out of fuel, which could be delayed with a larger machine. The convertible helicopter appears to be potentially capable of combining the advantages of the helicopter with those of the aeroplane. It will be noted that the convertible overtakes the other helicopters in a very short distance. It could be caught by the supersonic aeroplane at 600 miles out providing the latter had enough fuel; the subsonic jet aeroplane reaches it at about 1,200 miles, and the turboprop remains always about two hours behind it.

The final criteria are the comparative journey costs of the various forms of transport (Fig. 6) obtained by adding direct operating costs to airline costs, allowing for the load factor, multiplying by the stage length and adding the money equivalent of the journey time. It is evident that the supersonic aeroplane is not competitive at any stage length. The subsonic jet aeroplane cannot compete with the turboprop aeroplane, the difference between the two being about £2 throughout almost the whole range shown in the graph. The compound helicopter is notably better than the pure helicopter. The convertible helicopter has no rival between 200 and 530 miles stage lengths.

There remains a factor, which, even though it is economically imponderable, has significant economic effects. It is the convenience of the service, the comfort of the customer. Where comfort is lacking demand falls quickly. Avoiding changing on a journey greatly enhances the comfort, apart from reducing the risk of loss, luggage or similar mishaps. This is a factor in favour of the helicopter which could not be included in the above comparison.

Apart from the general field of commercial air transportation, there is a wide use for the helicopter in such specific applications as anti-submarine warfare, military transport where ground communications are restricted, casualty evacuation, pest control, power-line inspection, air charter work, geophysical exploration, fire-fighting services, and rescue operations such as were carried out during the floods in Holland last year.

The value of the helicopter in all special roles originates from its ability to move in a confined space, to hover and to land on an area not much greater than its undercarriage. It is therefore eminently suited for improvisation, which gives it mobility, ubiquity and adaptability in emergencies.

* In this brief summary, it is not feasible to give details of the assumptions on which the cost calculations were based. These assumptions, and the method of calculation adopted, were set out fully in Mr. Hafners paper.

DEVELOPMENTS WITH SYNTHETIC RESINS IN THE FOUNDRY*

By P. G. Pentz, B.SC.†

During the mixing of the dry sand and powdered resin in the shell moulding process, and again during investment, there is usually a certain amount of dust which is not completely suppressed by the normal addition of small proportions of mineral oil, paraffin or other liquid wetting or " pick-up " agent. This dust is partly resin and partly sand. Large-scale shell-moulding operations without adequate precautions are, at these stages (mixing and investment), at best unpleasant, and at worst a potential danger to health. The fact that expensive resin can escape into the air as dust is also evidence of inefficiency in the moulding mixture. Close examination of the material in the dump box will frequently disclose another source of waste, namely, segregation of the light particles of resin from the much heavier sand grains. Attempts at blowing shell cores with compressed air immediately show up the same serious defect: the powdered resin is separated from the sand.

Consideration of these defects in the standard process led us, some years ago, to the conclusion that the bonding efficiency of the resin would be improved, so that lower proportions would give the necessary strength, and that the defects mentioned would be eliminated, if means could be found of distributing the resin evenly over the surface of the sand grains and fixing it so that it remained where it could do most good when caused to flow under heat during investment and cure. Initial attempts at achieving this took the line of adding liquid resins to the sand as " pick-up " agents; the idea was that the liquid resin would first be made to form a sticky film on the sand to which the powder would then adhere. It was found, however, that in the proportions needed to suppress dusting and prevent segregation, the liquid resin impaired the free-flowing properties essential in a moulding mixture for investment by dumping; and no great improvement in shell strength could be observed.

A more fundamental solution to the problem was then sought with results which seem certain to have a most important effect on the status of shell moulding. From a consideration of the problem in the light of the specific properties of the shell-moulding resins, the conclusion was reached that the solid resin should be brought into liquid form, the sand grains uniformly coated with it, and finally restored to a free-flowing condition by suitable processing.

Many different ways of achieving the pre-coating of sand have been tried in our laboratories during the last two years. A practical and economical method of producing pre-coated sand in bulk quantities has not been easy to find, but we believe success is now in sight. It should not be long before we can announce the availability of pre-coated sand in ample quantities. It is too early to estimate with any accuracy the cost of processing the sand, but this much can be stated: the pre-coated sand is dry, free-flowing, storable, free from dust, capable of being blown without segregation, makes good shells, strips more easily from the pattern and gives higher strength than the same proportion of powdered resin in the conventional mix. Refinements in the process and large-scale manufacture of the pre-coated sand can be expected to lead to economies, so that a substantial reduction in the cost of shell moulds seems a reasonable prospect. Even were that not achieved, the other advantages and particularly the simplification of the problem of blowing shell cores, would make a great difference to the scope of shell moulding.

A serious obstacle to the use in jobbing foundries of shell moulds is the need for expensive metal patterns. Some work has recently been done with a steel foundry interested in the possibility of making quite large castings in shell moulds. The technique developed here has been to mix about 10 per cent. of a substantially neutral cold-setting resin of the phenolic type with a fine silica sand and ram it up as a facing about 1 in. thick on a wooden pattern previously coated with a release agent. After allowing the resin to set hard overnight, the pattern was drawn, leaving a strong, dry, smooth-surfaced

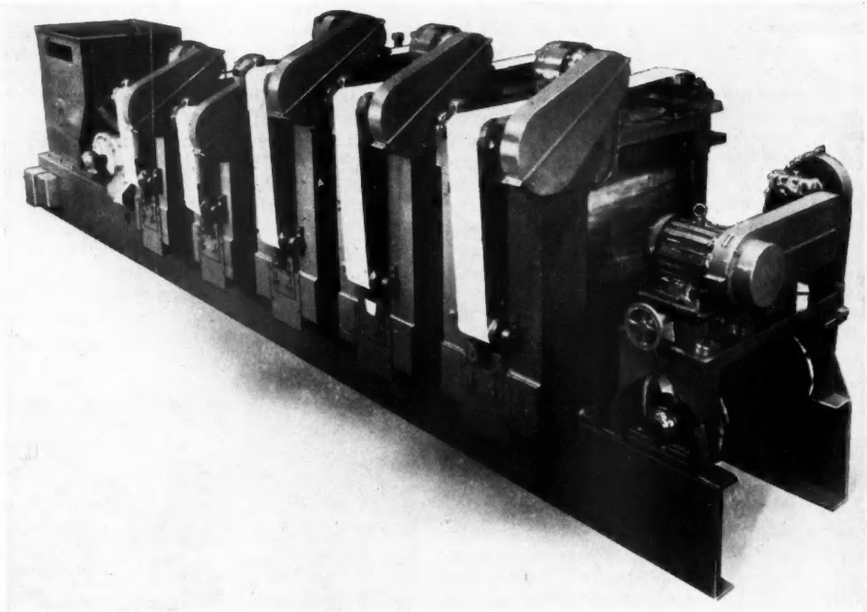
* Extracts from a paper presented at a meeting of the Institute of British Foundrymen, Coventry Branch, on Tuesday February 16, 1954.

† Of Leicester, Lovell and Company, Limited, Southampton.

mould. The application of a coating of a newly-developed furane* resin further improved the surface. A specimen mould was prepared in this way in the laboratory on the same pattern as was used for shell moulds and a comparison of the surfaces showed little difference.

The cold-setting furane-resin coating mentioned has other interesting potential applications in the foundry, some of which have recently been explored. It is available in a form which can be sprayed on to the surface of an ordinary sand mould and then cured by igniting the solvent contained in the furane-resin coating. The resulting skin on the mould has the hardness, water- and chemical-resistance and also the good temperature-resistance (superior to phenolic resins) which are characteristic of this new class of resin. These good properties of the furane resins also seem likely to find application in their use as a protective surface coating on core carriers made with ordinary liquid synthetic resin core-sand mixes.

* Furane or furfurane, C_4H_4O, is a colourless liquid insoluble in water, which forms resins in the presence of mineral acids.—Ed. E.



Crushed material from the hopper at the far end falls on a moving belt; magnetic particles are drawn up by a series of magnets and held against cross-belts which carry them away till they fall into discharge chutes. The magnets are arranged to remove the materials in order of susceptibility.

SEPARATING GRANULAR MATERIALS BY THEIR MAGNETIC PROPERTIES

CONVEYOR MACHINE FOR CRUSHED ORE

A machine designed for the continuous separation of ores according to their magnetic properties has been introduced by Rapid Magnetic Machines, Limited, Lombard-street, Birmingham, 12. The illustration gives a general view from the delivery end.

Crushed ore is placed in the hopper which can be seen at the far end of the machine, and is fed on to the main belt by a mechanically-vibrated feed-tray which spreads it evenly. The machine works most efficiently when the ore is of uniform size. The main driving-motor is totally enclosed and drives the main belt through gearing and a chain. This belt is of rubber and canvas construction and is about $\frac{1}{4}$ in. thick; three widths are available: 6 in., 12 in. and 18 in. Above the main belt are the magnets with the cross-belts running round them. There can be as many as are required for the different ores and they are arranged in order of power, so that the most magnetic material is extracted first and the rest in order of their susceptibility. The first cross-belt has a permanent magnet but the others are electrically energised. An example of separation is a machine dealing with a monazite-bearing sand. Magnetite would be removed by the first cross-belt, ilmenite by the second, garnet by the third and monazite by the last, leaving the sand to pass on.

As the ore passes below the cross-belts, the magnetic portions are attracted upwards by the magnets and rest against the cross-belt. This carries them sideways until, when beyond the magnetic field, they fall off into the collecting boxes.

The cross-belts are also rubber and canvas; each is driven by a $\frac{1}{3}$-h.p. motor and runs on aluminium pulleys. The capacity of the machine varies with the material to be treated and also with the size and number of magnets employed. The five-belt machine illustrated is approximately 20 ft. long and weighs 12 tons. A single cross-belt machine with a 6-in. wide conveyor would consume approximately 800 watts, while one with an 18-in. conveyor and seven cross-belts would take 6,750 watts.

33-KV ON-LOAD TAPPING SWITCH

19 Ratios from 10 Tappings

The range of on-load tapping switches manufactured by the General Electric Company, Limited, has recently been augmented by the introduction of a new unit for use on transformers with 33-kV windings. This switch – type O.L. 33/300/19 (N) – has a current-carrying capacity of 300 amperes and, by using a centre-tapped reactor, provides a maximum of nineteen voltage ratios with ten tappings on the winding. The minimum step voltage recommended is 1·25 per cent.

The switch is normally arranged for remote push-button control, but local push-buttons can also be used, while automatic control can be provided by a voltage-regulating relay; facilities for manual operation are also included. For supervisory control, auxiliary switches can be fitted to give remote indication. If two or more units are to work in parallel, further auxiliary switches can be provided to energise an out-of-step relay which, in turn, operates an alarm and locks out the control circuit if the transformers are out of step.

The complete tapping switch is assembled as a self-contained unit and is attached to the transformer by a bolted flange. The unit is divided into three compartments, as may be seen in the illustration; one houses the 3-phase tap-selector switch; a second houses the cam-operated diverter switches which are of the single-break type; the third contains the intermittent gear and driving mechanism. The selector and diverter compartments are oil-filled.

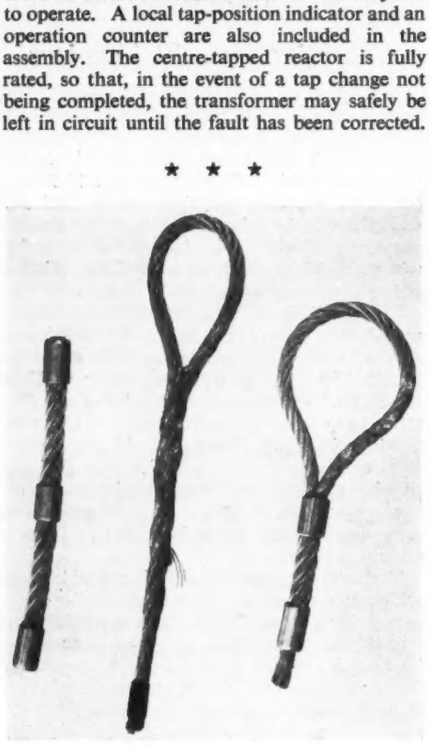
The intermittent gear comprises two maltese-cross gears, one for operating the selector switches and the other for the diverters, and is coupled to the driving mechanism by duplex roller chain. The intermittent gear not only governs the timing of the operations of the selector and diverter switches, but also serves to lock them in position at the end of each tap change. The sequence of operation is such that there is no possibility of the selectors opening under load. The driving mechanism comprises three sections – the driving and gear reduction unit, the manual operation unit, and the auxiliary control-switch unit – and is arranged for easy servicing. Insertion of a removable handle for manual operation of the mechanism automatically disconnects the driving motor both mechanically and electrically.

The auxiliary control switches are mounted on a Bakelised-paper panel so that all contacts, terminals and wiring are readily accessible. Limit switches prevent over-running the end

33-kV on-load tapping switch for mounting on a transformer.

tapping positions, and a mechanical limit stop is fitted to arrest the motor drive should they fail to operate. A local tap-position indicator and an operation counter are also included in the assembly. The centre-tapped reactor is fully rated, so that, in the event of a tap change not being completed, the transformer may safely be left in circuit until the fault has been corrected.

* * *



The wire-rope splices shown on the left and right are made by unlaying part of the rope, relaying it over the intact part, and finally making the splice by two or three ferrules squeezed between dies.

WIRE ROPE SPLICING

A quick and easy method of splicing wire ropes using two or three steel ferrules, examples of which are shown in the accompanying illustration alongside a conventional splice, has received the approval of Lloyd's and the Ministry of Transport, among others. It was developed in the United States by the American Chain and Cable Company, and the agents for it in this country are Maritime Stores, Limited, 8-10 Lancelot's-hey, Liverpool, 3, who have named it the "Marisplice." The ferrules are cadmium plated and are being made in standard sizes for ropes from 1 in. to 5 in. circumference.

In this method of splicing, the wire rope is unlaid and relaid in the lay of the rope. The ferrules, previously threaded on the rope, are then pushed over the splice to the desired position, placed between a pair of dies and firmly pressed until they grip the splice.

Proving tests have been made on a wide range of wire ropes joined by this method in the National Physical Laboratory, Teddington, and the Sheffield Testing House. In a series of pulling tests carried out by the latter organisation, 60 double-ended slings were examined. The results of two typical tests are given: a wire rope of 1 in. circumference having six strands of 19 wires and rated at 3 tons failed at 71·8 cwt., three strands fracturing together near to the inner sleeve with a rope extension over a length of 2 ft. 4 in. of 0·98 in. In the other case chosen, a rope of 3 in. circumference, rated at 24 tons and comprising six strands of 37 wires, four strands fractured, three inside the sleeve furthest from the loop at one end and one inside the opposite sleeve at the other end, at a load of 616 cwt. In this case the extension over 9 in. was 0·08 in. with a load of 15 tons and the final extension over this length was 0·49 in.

HOT-SPRAY UNIT FOR INDEPENDENT TWO-GUN OPERATION

A modified version of the hot-spray unit developed by the Atlas Diesel Company, Limited, Wembley, Middlesex, has been introduced recently, which makes possible the continuous operation of two guns used independently. The principal modification comprises an adaptor fitted to the side of the distributor block, which allows two guns to be fed from the unit, with compensation of the fluid pressure in both lines. The new unit is fitted with a 3½-kW heater instead of a 2¼-kW heater. Users of the old type of H3B hot sprayer can adapt their plant for two-gun operation by fitting the adaptor and higher-powered immersion heater. A further modification consists of an improved pump gland which is designed not to break down even if the plant is run at too high a pressure or with faulty maintenance. The manufacturers state that, unless regular and careful cleaning of the adaptor is carried out, the use of pigmented materials in the two-gun plant is not recommended.

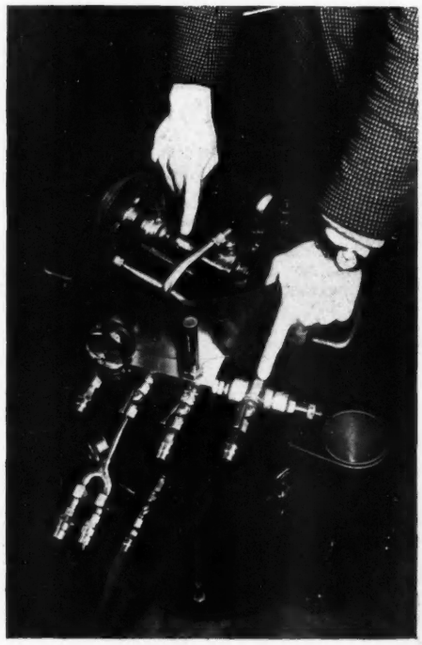
The unit, shown in the photograph, consists of three main sections: the pump section (upper part), the element section (intermediate part), and the water section (lower part). The pump section includes the paint pump, which is driven from a three-phase or single-phase flameproof electric motor by V-ropes, the coupling plinth with cocks and connections for paint hoses, the two-gun adaptor unit and a thermometer and gauge for controlling the temperature and pressure of the paint. The element section includes a single-phase 3,500-watt element, a thermostat with signal lamp, and connections for the air hoses to the spray guns and for the paint coil. The thermostat is manually operated. The water section comprises the vessel in which the elements, the paint coil, and the pipe from the thermostat are suspended in a water bath, with a water funnel, a water-level indicator pipe and a drain cock. The three sections are held together by eccentric locks. In use, the unit is attached to a pressure container, spray guns and air transformer. If the unit is to be used in a spray booth, an automatic pressure switch is incorporated which switches off at an air pressure of 15 lb. per square inch as a protection against the possible ignition of fumes from the spray guns, or the paint shop in general.

In operation, compressed air to the unit passes first to the air transformer and its reducing valve on top of the pressure container. Here it is divided into two streams—one for the pressure container, and the other to the spray gun. On the rear side of the coupling plinth a small hole directs scavenging air round the electric connections inside the intermediate section and also in the upper section, thus preventing inflammable gases from the atomised paint entering the unit. In addition, as already mentioned, an automatic pressure switch is connected in the air line between the pressure container and the coupling plinth to prevent the connecting of the elements before scavenging air enters the intermediate part.

From the pressure container, the paint is passed through the paint intake on the coupling plinth to the pump, which forces the paint through the paint coil, suspended in the water container, to the hoses of the spray guns. Here the paint goes partly to the spray gun whilst passing the two-gun adaptor and partly returns through the return hose to the coupling plinth and to the suction side of the pump. The paint coil is heated by the water, the temperature of which is regulated by the thermostat controlling the heater element.

In starting up, the air pressure is set after passing the air transformer to about 50 lb. per square inch by means of the reducing valve. The air cock on the coupling plinth is closed. The pump motor is started and the electrical supply to the heater element is switched on. The paint pressure is adjusted to about 20 lb. per square inch and the thermostat is adjusted until the signal lamp indicates that the element is switched on. When the required temperature has been reached, the thermostat should be re-adjusted until the element is switched off and the signal lamp goes out. When the temperature falls the element will be switched on automatically and the signal lamp relighted. The lacquer is sprayed into a container until the jet is smooth and free from disturbances ensuring that the paint is free from air. The air nozzle is then screwed on to the guns and the air cock on the coupling plinth is opened.

The main features of the guns are as follows: the nozzle centralising on a cone-and-ball principle; a precision-ground lapped needle and nozzle; lightweight construction; simple construction for cleaning and maintenance; and chromium plate finish. The fan-spray control is extremely sensitive, and, with correct manipulation, is claimed to effect a substantial saving in the material being sprayed.



Two-gun hot-spray unit. Each gun can be independently operated.

* * *

INDENTED BAR REINFORCEMENT FOR CONCRETE: ERRATUM

In the description of Tentor bar reinforcement for concrete on page 350, *ante*, it was implied that the London County Council were already permitting stresses of 33,000 lb. per square inch for cold-worked bars. This is not the case, the position being that the Council will at present only permit a tensile stress of 30,000 lb. per square inch in Tentor bars subject to an application for a waiver of the by-laws. Certain other local authorities are, however, permitting the higher stresses.

SMALL NON-FERROUS COMPONENTS SPOT WELDED

The 4-kVA electronically-controlled spot welder illustrated in Fig. 1 was originally designed in the research laboratories of the General Electric Company, Limited, for their own use in connection with the joining of very thin wires and sheets of non-ferrous metals. It contains a number of features which enable accurate repetition to be performed on materials for which this process has not hitherto been considered suitable. Both current and voltage are fully controlled, graduated scales being provided so that the setting may be recorded. The heavy welding-current pulses can be adjusted to last from one to six cycles by an electronic circuit and are synchronised so that the weld always starts at the same point in the cycle. The top moving electrode is mounted so that there is a true straight-line motion between it and the lower electrode. It is carried in a low-inertia holder, so as to provide the quick follow-up necessitated by the rapid collapse of the metal that is being welded.

Fig. 1 The 4-kVA General Electric electronically-controlled spot welder being used at the New Southgate works of Standard Telephones and Cables, Limited, to weld a nickel-silver residual plate to an iron relay core. This machine can handle very small components successfully.

Operation is controlled by a pedal and the transmission mechanism is so designed that very small and delicate parts can be handled and accurately placed in position. The weld switch is operated automatically only after the pre-set electrode pressure has been applied, and the completion of a weld is shown on an indicator. Ample working space is available on the machine and the use of a welder head which can be adjusted in height and moved radially, as well as an accurately-machined and slotted baseplate, greatly facilitate the use of jig assemblies.

A number of these welders have been installed at the New Southgate works of Standard Telephones and Cables, Limited, one being employed in the laboratory for the development of new applications of the process and others on full-scale production.

Owing to the shortness of the welding times that can be obtained, the heat round the weld is strictly localised. This may be illustrated by the assembly of the coaxial socket shown in Fig. 2. This operation involves the connection of two pieces of silver-plated beryllium-copper, each 0·015 in. thick, and is effected without annealing the surrounding metal.

Heat localisation is also necessary when tinned nickel wire and strips are welded to the tinned Kovar terminals of a miniature relay, as shown in Fig. 3, since the welds are close to a glass-to-metal seal and thermal shock must be avoided. The wires in this case are 0·018 in. in diameter, while the strips are 0·06 in. thick and the terminals 0·04 in. in diameter. The welds are effected with a minimum displacement of the plating.

As absolute cleanliness is essential if thin sheets of metal are to be joined without distortion, electrodes must normally receive constant attention to prevent dust accumulating on the parts to be welded. Constant cleaning is, however, unnecessary on this machine. In the deaf-aid diaphragm illustrated in Fig. 4, a slug of Permalloy B 0·02 in. thick has been welded to a diaphragm 0·005 in. thick without distortion and without marking the selected face.

Another example of the use of this machine is the welding required for a relay spring of thin dissimilar metals with near extremes in electrical conductivity. The contact is of cadmium silver 0·025 in. thick and 0·125 in. in diameter and is welded to a nickel-silver spring only 0·01 in. thick without marking the contact surface. In the assembly of a spring plug body the difficulty of welding brass is aggravated by the need to join it to two nickel-silver springs each 0·018 in. thick by a common weld. The machine enables the two thicknesses of spring to be welded simultaneously against a projection at the end of the 0·108-in. diameter body. Finally, the assembly of a terminal involves the welding of a total thickness of 0·04 in. of silver-plated nickel-silver with a minimum displacement of low conductivity plating.

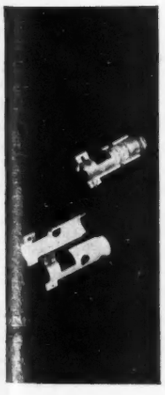


Fig. 2.

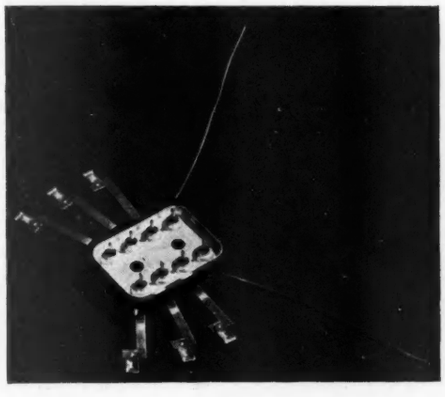


Fig. 3.

Fig. 4.

Fig. 2 Assembly of two pieces of silver-beryllium copper, each 0·015 in. thick, for a coaxial socket. Fig. 3 Tinned nickel wire and strips for welding to the tinned Kovar terminals of a miniature relay. Fig. 4 A deaf-aid diaphragm of Permalloy B, 0·005 in. thick, to which a slug 0·02 in. thick has been satisfactorily welded by the electronically-controlled machine described in this article.

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CORRUGATED ALUMINIUM CLADDING

Expected Life of 100 Years

Investigations during recent years have shown the possibilities of using aluminium sheet as a roofing material, and now the Northern Aluminium Company, Limited, Banbury, Oxfordshire, have produced a corrugated sheet for this purpose. It is made of Noral 3-S, containing 1¼ per cent. of manganese, which increases the tensile strength without reducing the resistance to corrosion.

The profile of this sheet is not symmetrical in that the troughs are three times wider than the crests. The pitch length is 5 in. and the height from trough to crest is 1½ in. The narrowness of the crests offers good resistance to denting, and the 20 s.w.g. sheet will withstand the British Standard test load of 200 lb. on a 5-in. square. The sheet can be used with a span as large as 9 ft., which reduces the number of purlins and attachments required, particularly for industrial buildings. Thinner sheets of 22 s.w.g. are suitable for side walls.

Corrosion tests made by the American Society for Testing Materials show that aluminium corrodes more slowly than either zinc or copper, in either rural or industrial situations, but not under all marine conditions. Tests on Noral 3-S sheet, 0·036 in. thick, show that a life of 50 years can be expected in severe marine or industrial situations and over 100 years in tropical or rural environments; in each instance a safety factor of 2 has been allowed. "Life" in this case is defined as the time taken for the corrosion pits to penetrate the sheet completely.

★ ★ ★

SELECTOR PANEL FOR SERVICING PNEUMATIC PLANT

Equipment for simplifying the servicing and test of pneumatic plant which is normally automatically controlled, has recently been introduced by George Kent, Limited, Luton, Bedfordshire. It is designed particularly for use with their Mark 20 range of controllers and consists of a panel on which are mounted a selector switch, a regulator-signal indicator, a balance indicator and a hand control adjustment, together with the necessary pipe connections. The panel can be mounted in a convenient position and can be used without any interruption of continuous processes.

The selector switch has four positions: auto., manual, test, and service; and when in the last position the handle may be removed to prevent inadvertent switching while men are working on the gear. There is also a safety lock to prevent unauthorised use of the panel. The balance indicator shows the relationship between the automatic control setting and the manual setting, so that the two may be brought in line before the selector switch is changed, and any sudden surge prevented. In the test position the plant is manually controlled but the automatic-control mechanism functions normally, though separated from the regulator. In this way, alignment, leakage and other checks may be made.

45-TON ROAD HAULAGE TRAILER

A number of large trailers with detachable bogies have recently been made in this country. One example is the 45-ton trailer shown herewith, designed to carry heavy machinery and civil-engineering plant. It was built to the requirements of the Chief Engineer of the Office of Public Works, Dublin, by R. A. Dyson and Company, Limited, 76-80 Grafton-street, Liverpool, 8. The clear loading space between the cranks supporting the platform is 22 ft. by 8 ft. 10 in. and the width of the platform can be increased to 10 ft. 6 in. by opening 16 outriggers. The eight outriggers on the off-side can be seen in the illustration.

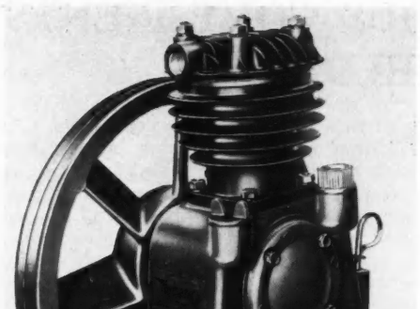
The normal ground clearance over the full wheel-base is 1 ft. 9 in. For negotiating humped-back bridges the clearance can be increased to 2 ft. 3 in. or decreased to 6 in. to allow extra head space when passing beneath low arches. To make the change, hydraulic jacks built into the cranks are lowered to the ground and four pins locating the crank heads on the carriage frames are removed. The jacks then take the full load and raise or lower the platform as required. The pins are replaced in the appropriate pair of holes and the jacks retracted.

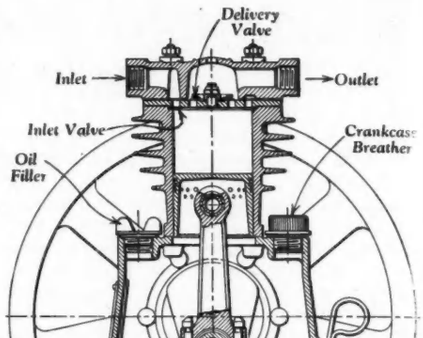
The platform may also be lowered to the ground and the bogie carriages and cranks withdrawn. The power for operating the jacks is drawn from a small petrol-engine driven pump mounted on one of the carriages.

The trailer can be towed from either end and the trailing end can be steered manually from a removable platform, or by a vehicle acting as a pusher, or the steering may be locked. A winch-type of steering gear is used and the turning moment is transmitted to the bogie through chain and sprocket gears.

A ball-ended king pin is used between the crank frame and bogie at each end and the bogie itself can be turned through 180 deg.; this arrangement allows the whole trailer to be moved sideways. A stabiliser is placed each side of the king pins to prevent swaying of the platform. Normally the stabilisers on one carriage are retracted so that the platform is supported by three-point suspension.

There are 16 wheels with Michelin G20 "metallic" tyres. Each wheel has a 16½ in. by 5 in. 2LS Girling brake and drum operated by a Clayton Dewandre two-line air-pressure system. Should the coupling between the tractor and trailer fail the brakes are applied automatically. Full oscillation of the axles is allowed by four Woodhead trunnion-ended springs fitted to each bogie.





The Hymatic 200 SAS single-cylinder single-stage industrial compressor unit, with a displacement of 5·25 cub. ft. per min. at 750 r.p.m. at a working pressure of 100-150 lb. per sq. in.

INDUSTRIAL COMPRESSOR UNIT

DESIGNED FOR RELIABILITY UNDER ARDUOUS CONDITIONS

Designed to achieve a long working life with the minimum of attention, a pedastal-mounted compressor unit, the 200 SAS, is now in quantity production by the Hymatic Engineering Company, Limited, Redditch, Worcestershire. With a displacement of 5·25 cub. ft. per minute at 750 r.p.m. and a working pressure of 100 to 150 lb. per square inch, the 200 SAS is suitable for such duties as spray painting, spraying horticultural and insecticide solutions, pneumatic greasing, tyre inflation, the operation of pneumatic tools, braking systems, jigs and fixtures, etc. When necessary, the unit may also be operated at 1,000 r.p.m. to give a displacement of 7 cub. ft. per minute against a working pressure of 100 lb. per square inch.

The compressor, shown in the accompanying illustrations, is of the single-stage type. The single 200-c.c. capacity high-duty cast-iron cylinder, bore 2·67 in. and stroke 2·16 in., is heavily finned, which, together with the finned cast-aluminium cylinder head and ample inlet and outlet ports, ensures that a consistently low delivery temperature is maintained.

Passing through a filter and silencer, the inlet air enters the cylinder through a large-diameter low-lift lightweight annular valve. On the up stroke of the piston the air is compressed and passes to the delivery connection via a central annular plate valve. Unlike the air inlet valve, this is fitted with a wave-type annular spring.

The aluminium-alloy piston is fitted with two compression rings and an oil scraper. A case-hardened steel gudgeon pin is located by circlips, and the forged-steel connecting rod carries a phosphor-bronze bush at the small end, and steel-backed white-metal-lined shell bearings at the big end.

The high-tensile forged-steel crankshaft, carried in large diameter ball bearings to minimise friction losses and to ensure complete reliability, is housed in a cast-aluminium crankcase with bosses for a breather and oil filler plug at the top. A dip rod on the big end regulates the splash type lubrication of the running gear.

The driving-end bearing is carried in a cast-iron housing which also holds the shaft seal. A flanged distance piece between the bearing and the flywheel boss serves a triple function – it acts as a distance collar, clamping the inner race of the bearing; it provides a hardened surface to co-operate with the lip on the seal; and it is convenient for extracting the seal.

A fan pulley, grooved to accommodate twin V-belts and of adequate dimensions to ensure a large flow of cooling air over the cylinder, is keyed to the shaft and retained by a central fixing screw.

Weighing 38 lb. complete, the Hymatic 200 SAS absorbs about 1 h.p. at 750 r.p.m.

This 45-ton trailer can have a clearance beneath the platform of 6 in., 21 in. or 27 in. The bogie carriages can be detached, and when travelling over winding roads the rear bogie can be steered independently.

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ROTATING LATHE CENTRES

Recent additions to the range of J. and S. Lunzer rotating centres, which are made by Austin and Lang, Limited, Heather Park-drive, Wembley, Middlesex, cover Morse taper sizes from No. 1 to No. 6 and parallel shank diameters from ¾ in. to 2⅛ in. The agents for these centres, which incorporate features designed to eliminate chatter and swarf penetration, are A. A. Jones and Shipman, Limited, Narborough-road South, Leicester.

BI-METALLIC BONDING

PROPERTIES OF ALUMINIUM AND FERROUS METALS COMBINED

The " Al-Fin " process, which enables aluminium and its alloys to be joined by a molecular bond to steels and cast iron, and the production of " Duaflex " steel oil-control piston rings, which are designed to provide an efficient oil seal, even in irregularly worn cylinders, and to reduce bore wear in new ones, are two aspects of the work carried out at the Wellworthy factories, a Press tour of which took place recently.

Mr. John W. Howlett, O.B.E., managing director and chairman of Wellworthy Limited, the head office of which is at Radial Works, Lymington, Hampshire, presided at the luncheon which preceded the visit to the factories. In his speech, he said that the company had been associated, since it was founded in 1918, with the development of the internal-combustion engine and had been engaged continuously for 35 years in the production of pistons and piston rings, cylinders, aero-engine castings and a variety of other components.

The bonding of aluminium with other metals is made difficult by an oxide film which rapidly forms on its surface when it is exposed to the air. This problem was independently solved by Wellworthy Limited during the war but, prior to this, the Al-Fin Division of the Fairchild Engine and Airplane Corporation of Farmingdale, Long Island, New York, U.S.A., had developed a closely similar process and had been operating it since 1941. A licence was obtained from the American firm and bi-metallically bonded components have been made in this country by the Wellworthy company since that date.

In the Al-Fin process, the ferrous member – for example, a cast-iron cylinder liner – is first prepared and the areas where a bond is not required are masked. The liner is then immersed in molten alloy and remains below the surface until the aluminium has attacked the iron, and the bond, which has an approximate chemical composition of $FeAl_3$, is complete. The bond, as can be seen in the micro-photograph (Fig. 1), is uniform. The liner is then placed in the die and the casting metal (pure aluminium or aluminium alloy) is poured in the normal manner, forming the extended fin section.

Any oxide formed on the melted surface by contact with the air is peeled off by the rising metal and floats to the surface of the casting, leaving a clean inter-metallic bond. Nitrided or carburised steel surfaces cannot be joined to aluminium in this way. The difficulty may be avoided, however, by masking before, or grinding after, the surface hardening takes place.

OTHER USES OF AL-FIN PROCESS

Until now the process has been largely confined to the manufacture of components for the motor industry, but it is believed that there are many other circumstances, throughout industry, in which it might profitably be employed. Mr. C. A. Clarke, chief engineer of Wellworthy Limited, said that the bonding of aluminium and steel might prove useful wherever moving parts were required to be light to minimise inertia, but sufficiently hard at points of contact to resist wear. An example is the piston-ring groove insert shown in Fig. 2.

Other qualities of aluminium and its alloys which might beneficially be combined with those of steel are: high conductivity of heat – making it suitable for use in heat-exchangers and in engines or machines where heat must rapidly be dissipated from points of heat concentration; resistance to oxidation and corrosion; and its non-toxic property, which permits its application to food plant.

The Ampress aluminium foundry, in which the operation of the Al-Fin process was witnessed, is equipped, as can be seen in Fig. 3, with bale-out furnaces. These provide the molten metal for die-casting, which is carried out on the adjacent benches, and are themselves continually supplied from a Monometer 30-cwt. oil-fired mechanised rotary furnace. The furnace, which consumes 8 gallons of oil for every ton of aluminium melted, was made by the Monometer Manufacturing Company, Limited, Savoy House, 115-116 Strand, London, W.C.2.

The tour continued with a visit to the Stanford-road factory where machine shops, tool room and inspection department were seen. In order to maintain high quality in the production of internal-combustion engine components, 100 per cent. inspection is employed, and the high-speed checking of piston rings for shape, thickness and gap-size is performed on a large scale.

Among the many sizes and types of piston ring made at the Wellworthy factories is the recently introduced Duaflex oil-control ring, which is shown in Fig. 4. The object of this design is to combine the wearing quality of hardened steel with the efficiency of spring steel in preventing the passage of oil. This ring, the makers claim, not only reduces wear in new cylinders but adapts its shape to the bores of already worn cylinders, thus often eliminating the need for a re-bore. It is a chromium-plated ring and therefore unsuitable for bores which are also chromium-plated, but for this purpose a second form of Duaflex ring has been developed.

Fig. 1

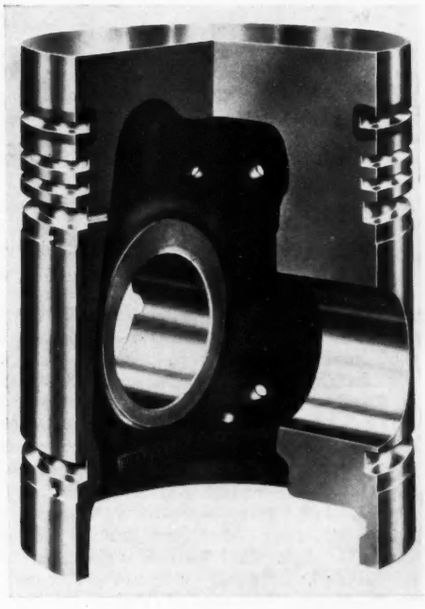


Fig. 2

By means of the " Al-Fin " process, aluminium and its alloys can be joined to ferrous metals by a molecular bond, the uniformity of which is revealed by the microphotograph in Fig. 1. This process has a special application to moving parts which must be light to minimise inertia but sufficiently hard at points of contact to resist wear. Fig. 2 shows in section a steel piston-ring groove insert bonded to an aluminium alloy piston.

Fig. 3 In this photograph of the Ampress aluminium foundry can be seen bale-out furnaces and, at the far end of the shop, the Monometer 30-cwt. rotary furnace which feeds them. The premises of Wellworthy Limited also include a steel foundry.

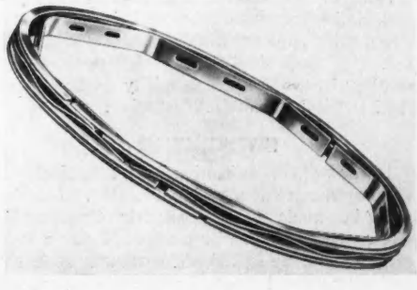


Fig. 4 The " Duaflex " oil-control piston ring combines the wearing qualities of hardened steel with the efficiency of spring steel in resisting the passage of oil to the upper cylinder. It is designed both to reduce bore wear and to compensate for it in an irregularly worn cylinder.

ELECTRICAL ENGINEERS' EXHIBITION

Display by Makers and Contractors

The third Electrical Engineers' Exhibition (organised on behalf of the Association of Supervising Electrical Engineers) was held at Earl's Court, London, S.W.5, from March 16 to 20. The exhibition was more than twice as large as in 1953 both in regard to numbers of exhibitors (179) and area occupied. It was formally opened by Sir Henry Self, K.C.B., president of the British Electrical Development Association.

CONTROL OF MOTOR SPEED

Among the items on the Lancashire Dynamo Group's stand was a Varionic drive developed by the Nevelin Electric Company, Limited. This employs six grid-controlled Nevitron rectifier tubes (described in ENGINEERING, vol. 174, page 373 (1952)), connected in bridge and is suitable for motors up to 100 h.p.; for larger motors two units may be run in parallel. Motor speed can be controlled over a wide range.

Oliver Pell Control, Limited, were showing a large selection of Besson and Robinson's relays, among them being a coil which would work satisfactorily at 250 deg. C. The use of Bicoloc as an insulating varnish was shown and coils using it could be encased in a moulding with dimensional tolerances of $\pm$ 0·005 in. Other relays were shown by Londex, Limited, whose new additions included a triple-pole mercury-switch contactor and an electronic relay.

Included among the wide range of products on the Ferranti stand was a complete testing equipment for single-phase watt-hour meters. Designed for speedy and simple operation, it can accommodate 20 meters under test and the same number "warming-up." In the control panel there is a sub-standard instrument which controls a stroboscopic light mounted above the row of meters and also the revolution counters mounted below; the former is used for high loads and the latter for low. Full current adjustment is possible and meters may be set to run at a small percentage fast or slow as desired. Clip-on ammeters with ranges up to 1,000 amperes and a power factor relay (described on page 315, *ante*) were also on show.

Evershed and Vignoles, Limited, were displaying their "Megger" test instruments, of which the largest insulation tester will generate 10,000 volts. This is obtained from a static rectifier operating from the alternating-current mains through a transformer. The Tinsley thickness gauge was also on view and so were their miniature recorders.

A display by the British Electrical Development Association illustrated the work being done at the new Testing House at Leatherhead (ENGINEERING, vol. 176, page 489 (1953)). There were also displays by the British Electricity Authority and the Electrical Research Association.

SWITCHGEAR

In the switchgear section both manufacturers and contractors were well represented. Mention may be made of the Electric Construction Company, Limited, who were exhibiting a large range of gear up to 250 MVA capacity at 11 kV, including several types of contactor-starter; and of Cantie Switches, Limited, who showed their "Minunit" built-up switchboards using Brookhirst rotary switches up to 60 amperes capacity and their own switch-fuses above that. These boards are of small overall dimensions.

Thomas Bolton and Sons, Limited, were showing a large selection of copper products. Included among them were hard-drawn copper 'bus-bars with sections up to 10 in. by 1 in., commutator segments (a recent survey showed 1,700 different sizes were ordered in a year), plain wire, and samples of their "cellular" conductor designed for extra-high tension 'bus-bars of outdoor substations. This is both light in weight, mechanically strong and yet large enough to avoid corona effects.

New tools shown on the stand of the Martindale Electric Company, Limited, included two mica-cutters for commutators and the L.D.C. taping machine which won first prize as a labour-saving device at last year's exhibition and has now been put on the market. The winding-head can be clipped on to the wire (which may be round or square) where required and can tape up to 20 ft. per minute, either butting or overlapping the tape. It is supplied with a control pedestal and automatic stop-and-start device; wire up to $\frac{3}{8}$ in. diameter or $\frac{1}{2}$ in. by $\frac{3}{8}$ in. can be accommodated and the standard tape width is $\frac{5}{8}$ in.

On the English Electric Company's stand was an example of their "Superform" distribution board with quick make-and-break fuse-switches. These have retractable (telescopic) handles which enable them to be completely closed-in with a door. This gives a dustproof panel with a flush exterior and locking the doors prevents unauthorised operation of the switches.

OIL-OPERATED GEARBOX FOR FOUR 2,000-H.P. ENGINES

An oil-operated reverse-reduction marine gear unit believed to be the largest of its type in the world has been made by Modern Wheel Drive, Limited, Lindo Lodge, Stanley-avenue, Chesham, Buckinghamshire. It has been designed to take the drive from four Diesel engines to one common shaft, and will transmit 8,000 h.p. The reduction ratio is $4\frac{1}{2}$: 1 and the complete gearbox unit weighs 23 tons.

The gear casing has been fabricated from mild steel and measures 9 ft. in height by 11 ft. by $7\frac{1}{2}$ ft. Gunmetal bearings, lined with white-metal, carry the four input shafts. The flange couplings on two of the input shafts can be seen in the illustration and the rear-bearing covers of the other two can be seen beneath them. The large flange in the centre is the main coupling for the propeller shaft.

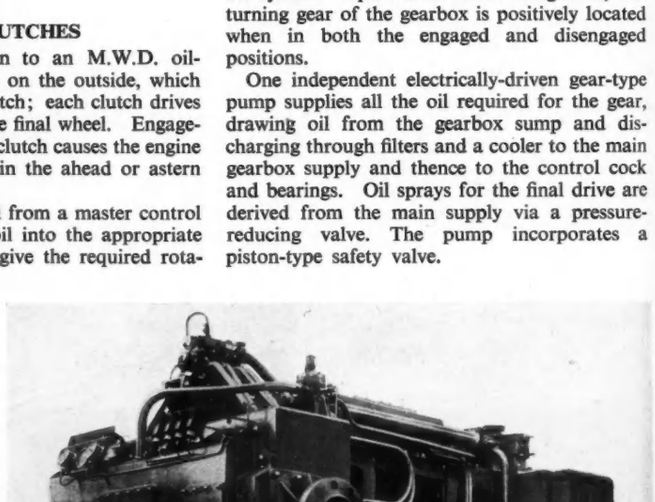
GEAR CLUTCHES

Each engine drives on to an M.W.D. oil-operated clutch, gear-cut on the outside, which meshes with a second clutch; each clutch drives a pinion meshing with the final wheel. Engagement of one or the other clutch causes the engine to drive the final wheel in the ahead or astern direction.

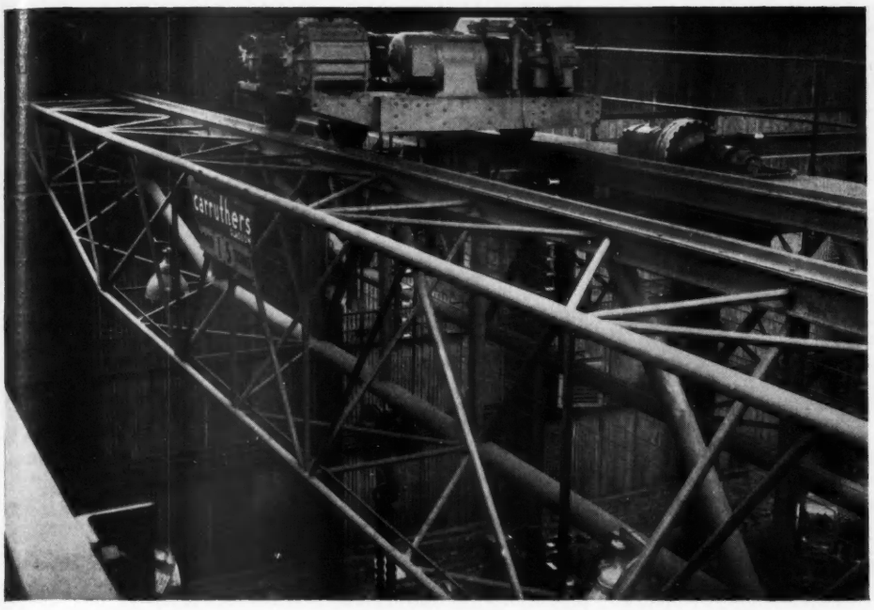
Operation is controlled from a master control cock which directs the oil into the appropriate oil-operated clutches to give the required rotation. Each engine can be individually isolated from the gearbox if required, by operation of a small lever on the master control cock, and ahead, stop and astern operation may be selected without regard to the number of engines driving. The operation of the master control is stated to be finger-light and is suitable for remote control.

The gearbox incorporates a hand-operated turning gear driving on to the final wheel. The engagement is interlocked with the control cock, so that when the turning gear is engaged, the oil supply to the control cock is cut off, it thereby being impossible to engage any engine into the gear, while accidental engagement of the turning gear while the gear is running is prevented by a piston, loaded from the gearbox oil system. Apart from these safeguards, the turning gear of the gearbox is positively located when in both the engaged and disengaged positions.

One independent electrically-driven gear-type pump supplies all the oil required for the gear, drawing oil from the gearbox sump and discharging through filters and a cooler to the main gearbox supply and thence to the control cock and bearings. Oil sprays for the final drive are derived from the main supply via a pressure-reducing valve. The pump incorporates a piston-type safety valve.



Four engines developing a total of 8,000 h.p. are coupled to this reverse-reduction marine gear unit. One or more of the engines may be stopped without affecting operation or control.



15-ton travelling crane, of tubular construction, made by J. H. Carruthers and Company, Limited, Glasgow.

OVERHEAD TRAVELLING CRANE OF TUBULAR CONSTRUCTION

GREATER LIFTING CAPACITY FOR GIVEN STRUCTURAL WEIGHT

In recent years, J. H. Carruthers and Company, Limited, Glasgow, who specialise in the manufacture of overhead travelling cranes, in addition to the manufacture of pumping plant of all types, handling appliances, etc., have been investigating the ratio between the lifting capacity and the deadweight of overhead cranes for different spans, with the object of evolving a design which would give a considerably lower deadweight for a given span than would be possible for conventionally designed cranes fabricated from rolled-steel sections.

The outcome of this investigation is the type of travelling crane illustrated on this page. This particular crane, of 55-ft. span, is entirely fabricated from tubular steel, excepting for the end-plates, traveller rails and wheel-carriages, and is believed by the makers to be the first of its kind to be built anywhere in the world.

SAVING IN WEIGHT

The weight of the main girder is stated to be approximately half of that of a similar girder fabricated from structural steel, and this saving in weight is evaluated by reference to the curves reproduced above, which show the weight in tons of the girders of 15-ton travelling cranes of different spans for both conventional and tubular forms of construction. From these curves it will be seen that in the case of a crane spanning 55 ft. there is a saving in weight of approximately 10 tons.

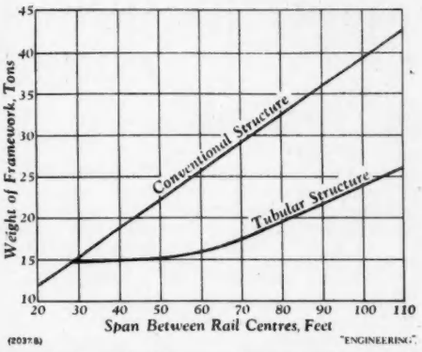
This saving in weight leads to several advantages, in that the load on the columns supporting the running rails is reduced by a like amount which, in the case of a building under contemplation, permits the use of lighter columns and foundations for any given lifting capacity. Conversely, by replacing a crane of conventional design with one of tubular construction, a greater lifting capacity can be obtained for the same total weight and load on the columns. As will be seen from the curves reproduced, the difference in weight between the two forms of structure increases with the span. The makers point out that, whereas a 15-ton crane of 100-ft. span and of conventional design can lift but 15 tons, a similar crane of tubular construction and with the same structural weight, can lift 20 tons; an increase of 33 per cent. in lifting capacity thus accrues without requiring any structural alterations to the building in which the crane is located.

A feature of the crane, as constructed from steel tubes with all joints butt-welded after profiling the tubes at their ends to obtain initial metal to metal contact before welding, is that, as far as dimensions will allow, the centre-lines of the tubes at all junctions intersect at a point, the outcome of which is that internal couples are reduced to a minimum and rigidity, therefore, with a marked freedom from whip results. The makers state that, in spite of the considerable saving in weight, the tubular framework is as rigid as its rolled steel counterpart while the deflections obtained under full-load and overload conditions " are similar to or better than those obtained from an equivalent conventional structure."

SENSITIVE CONTROL

Travelling, traversing and hoisting speeds are, of course, to suit users' requirements, and while a crane was recently supplied with a travelling speed of 420 ft. per minute, that of the 15-ton crane illustrated is 300 ft., the traversing and hoisting speeds being respectively 100 ft. and 20 ft. a minute ; this particular crane is also fitted with a two-speed gearbox giving a 2 to 1 speed reduction and permitting a load of 7½ tons to be hoisted at 40 ft. a minute.

Control of the three motions is from a driver's cabin suspended below the main framework at one end and may be obtained in the form of



Graph showing the approximate weight of the framework of 15-ton overhead travelling cranes with spans from 20 ft. to 110 ft. of conventional rolled-steel construction and of welded steel-tube construction.

what is termed " Microsen " creeping-speed crane control. As its name implies, the Microsen control enables such small movements to be made under power that they are scarcely noticeable, and it gives an extremely high degree of gentle and sensitive control. Microsen control may be fitted to any or all of the three motions, depending on the user's requirements, and it is used in conjunction with standard controllers or with contactors.

PRINCIPLE OF OPERATION

The principle of operation is that an electrical torque unit is used to preload the motor in such a way that it is, in effect, always working against the same torque no matter what actual load is on the crane-hook. The motor thus operates at a higher efficiency and power-factor and utilises the better part of its characteristics. The Microsen unit consists of a stationary direct-current field system, supplied from a single phase rectifier, and a form of squirrel-cage rotor. When the field is energised and the rotor rotates, currents are induced in it which interact with the magnetic field and produce a braking torque opposite in direction to the driving torque, and by suitably controlling the field excitation, any desired resulting speed characteristic may be obtained.

The operator of a crane fitted with Microsen control has no additional controls or levers to contend with and both creeping and full speeds are obtained by using a standard type drum or master controller. Moreover, there is no fear of the load dropping as both the raising and lowering movements are under power, while, when the controller is in the off position, movement ceases and the load is held suspended by an electro-mechanical brake.

The control lever for a particular motion has five positions corresponding to different degrees of excitation and resistance, and the first notch corresponds to a creeping speed of 10 per cent. of full speed at full load; for states of loading less than full load the creeping speed reduces to a smaller percentage of full speed.

For the crane illustrated, the full lowering speed is 20 ft. per minute at full load, and under Microsen control on the first notch this speed comes down to 10 per cent. of that figure, or to 2 ft. per minute; at half-load, however, the speed drops to 2½ per cent., which is 6 in. per minute.

This ability to move loads at high speeds with the advantage of being able to creep them into position, is a feature of the Microsen-equipped Carruthers' crane, and it has been demonstrated that it is possible to commence lowering a load of several tons at full speed and then slow down the movement so that the load may be brought to rest just clear of the floor.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

NORTH-WESTERN MANAGEMENT CONFERENCE. Fri. and Sat., April 2 and 3, at Southport, Lancashire. Organised in conjunction with the Federation of British Industries, the National Union of Manufacturers and the Institute of Industrial Administration, by the British Institute of Management, 8 Hill-street, London, W.1. Tel. GROsvenor 6000.

PRODUCTION INFORMATION CONFERENCE. Fri., April 2, to Mon., April 5, at the College of Aeronautics, Cranfield, Bedfordshire. Organised by Aslib and the Institution of Production Engineers. Apply to the secretary, Aslib, 4 Palace Gate, London, W.8. Tel. WEStern 6321. See our issue of February 26, page 271.

CONFERENCE ON THE YOUNG WORKER: EDUCATION FOR HUMAN RELATIONS. Sat., April 3, to Fri., April 9, at Manchester College, Oxford. Particulars obtainable from the secretary, Conference on the Young Worker, 15 Norham-gardens, Oxford. Tel. Oxford 58631. See also our issue of November 20, 1953, page 660.

SYMPOSIUM ON GAS ABSORPTION. Mon., Tues., and Wed., April 5, 6 and 7, at Birmingham. Organised by the Midlands Branch, Institution of Chemical Engineers. Further information obtainable from the secretary of the Institution, 56 Victoria-street, London, S.W.1. Tel. VICtoria 6161. See also our issue of March 12, page 325.

INTERNATIONAL CONGRESS OF SOUND RECORDING. Mon., April 5, to Sat., April 10, at Paris. Organised by the Société des Radioélectriciens, 10 Avenue Pierre Larousse, Malakoff, Seine, France.

ERGONOMICS RESEARCH SOCIETY'S CONFERENCE. Mon., April 5, to Thurs., April 8. See page 416.

CONFERENCE ON THE PHYSICS OF PARTICLE SIZE ANALYSIS. Tues., April 6, to Fri., April 9, at Nottingham University. Organised by the Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

CONFERENCE ON HARMFUL MATERIALS IN INDUSTRIAL ATMOSPHERES. Tues., April 6, at London School of Hygiene and Tropical Medicine, Keppel-street, London, W.C.1. Organised by the British Occupational Hygiene Society. Apply to Mr. P. C. G. Isaac, Public Health Engineering Laboratory, King's College, Newcastle-upon-Tyne, 1.

11TH RADIO COMPONENTS SHOW. Tues., April 6, to Thurs., April 8, at Grosvenor House, Park-lane, London, W.1. Organised by the Radio and Electronic Manufacturers' Federation, 22 Surrey-street, London, W.C.2. Tel. TEMple Bar 6740.

STUDY OF FAST REACTIONS. Wed., April 7, to Fri., April 9, at Birmingham. Organised by the Faraday Society, 6 Gray's Inn-square, London, W.C.1. Tel. CHAncery 8101.

CONFERENCE ON LUMINESCENCE, ESPECIALLY SOLID INORGANIC PHOSPHORS. Wed., April 7, to Sat., April 10, at Cambridge. Organised by the Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

PHYSICAL SOCIETY'S EXHIBITION. Thurs., April 8, to Tues., April 13, at the Royal College of Science main building, Imperial Institute-road, South Kensington, London, S.W.7. Organised by the Physical Society, 1 Lowther-gardens, London, S.W.7. Tel. KENsington 0048.

PLANT MAINTENANCE CONFERENCE. Fri., April 9, to Sun., April 11, at Roffey Park, Horsham, Sussex. Organised by the Society of Industrial Engineers, 28 Victoria-street, London, S.W.1. Tel. ABBey 6511. See our issue of February 26, page 263.

MILAN SAMPLES FAIR. Mon., April 12, to Wed., April 28, at the Palace of Nations, Milan. *Agent:* Dr. V. Schiazzano, 652 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 5521.

IRRIGATION AND DRAINAGE CONGRESS. Mon., April 12, to Sat., April 17, at Algiers. Organised by the International Congress on Irrigation and Drainage, 135 Rue Michelet, Algiers.

FOURTH INTERNATIONAL CONFERENCE ON ELECTRO-DEPOSITION AND METAL FINISHING. Tues., April 20, to Sat., April 24, at the Holborn Restaurant, London. Held under the auspices of the International Council on Electrodeposition. Apply to the conference secretary, Institute of Metal Finishing, 32 Great Ormond-street, London, W.C.1. Tel. CHAncery 6793. See our issue of March 12, page 327.

LIÉGE INTERNATIONAL FAIR. Sat., April 24, to Sun., May 9, at Liége, Belgium. Apply to the manager, Foire Internationale de Liége, 17 Boulevard d'Avroy, Liége, Belgium. See also our issue of August 14, 1953, page 218.

HANOVER LIGHT AND HEAVY INDUSTRIES FAIR. Sun., April 25, to Tues., May 4, at Hanover. *Agents:* Schenkers, Ltd., 27 Chancery-lane, London, W.C.2. Tel. CHAncery 6612.

AMERICAN SOCIETY OF TOOL ENGINEERS, 10TH INDUSTRIAL EXPOSITION. Mon., April 26, to Fri., April 30, at Philadelphia. Organised by the American Society of Tool Engineers, 10700 Puritan-avenue, Detroit 21, Michigan, U.S.A.

IRON AND STEEL INSTITUTE MEETING FOR YOUNG ENGINEERS. Mon., April 26, to Thurs., April 29, at Buxton. Apply to the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See our issue of March 19, page 355.

ROYAL SANITARY INSTITUTE HEALTH CONGRESS. Tues., April 27, to Fri., April 30, at Scarborough. Apply to the secretary of the Institute, 90 Buckingham Palace-road, Westminster, London, S.W.1. Tel. SLOane 5134.

INSTITUTE OF WELDING MEETING. Wed., April 28, to Sat., May 1, at Porthcawl and Bristol. Apply to the Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. Tel. SLOane 9851. See our issue of March 19, page 355.

INTERNATIONAL INSTITUTION FOR PRODUCTION ENGINEERING RESEARCH. Last week in April, at Aachen, Germany. Organised by the Collège International pour l'Etude Scientifique des Techniques de Production Mécanique, 233 Boulevard Raspail, Paris, 14e.

FOURTH INTERNATIONAL PAPER, PRINTING AND ALLIED TRADES EXHIBITION. Sat., May 1, to Wed., May 12, at the Grand Palais, Champs Elysées, Paris. Organised by the Salon des Techniques Papetières et Graphiques, 40 Rue du Colisée, Paris, 8e.

INTERNATIONAL CONFERENCE ON OIL AND COAL GASIFICATION. Mon., May 3, to Sat., May 8, at Liége. Organised by the Institut National de l'Industrie Charbonnière, 7 Boulevard Frère Orban, Liége, Belgium.

BRITISH INDUSTRIES FAIR. Mon., May 3, to Fri., May 14, at Earl's Court, London, S.W.5; Olympia, London, W.14; and Castle Bromwich, Birmingham. Particulars obtainable from the director, British Industries Fair, Board of Trade, Lacon House, Theobald's-road, London, W.C.1, Tel. CHAncery 4411; or from the general manager, British Industries Fair, 95 New-street, Birmingham, 2. Tel. Midland 5021.

EXHIBITION OF ARCHITECTURE AND BUILDING, AUSTRALIA. Mon., May 3, to Fri., May 28, at Sydney. Held in conjunction with the 1954 Australian Architectural Convention. Organised by the Royal Australian Institute of Architects, 16 Barrack-street, Sydney.

PHOTOGRAPHIC AND CINE EXHIBITION. Tues., May 4, to Sat., May 15, at Manchester. Organised by Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester. Tel. Deansgate 6363.

OXIDATION PROCESSES CONFERENCE. Thurs., May 6, to Sat., May 8, at Amsterdam. Apply to the secretary of the organising committee, Institution of Chemical Engineers, 56 Victoria-street, London, S.W.1. Tel. VICtoria 6161. See our issue of February 26, page 271.

SYMPOSIUM ON MIX DESIGN AND QUALITY CONTROL OF CONCRETE. Tues., Wed. and Thurs., May 11, 12 and 13, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Further particulars obtainable from the secretary, the Cement and Concrete Association, 52 Grosvenor-gardens, London, S.W.1. Tel. SLOane 5255. Alteration of dates. See also our issue of July 24, 1953, page 108.

INTERNATIONAL HIGH TENSION CONFERENCE. Wed., May 12, to Sat., May 22, at 28 Rue Saint Dominique, Paris. Organised by the Conférence Internationale des Grands Réseaux Electriques, 112 Boulevard Haussmann, Paris. Apply to the secretary, C.I.G.R.E. British National Committee, Thorncroft Manor, Dorking-road, Leatherhead, Surrey. Tel. Leatherhead 3423. See our issue of January 8, page 62.

PAPER AND PRINTING INTERNATIONAL FAIR. Sat., May 15, to Sun., May 30, at Dusseldorf. *Agents:* John E. Buck & Co., 47 Brewer-street, London, W.1. Tel. GERrard 7576.

FOURTH GAUGE AND TOOL EXHIBITION. Mon., May 17, to Fri., May 28, in the New Hall of the Royal Horticultural Society, Greycoat-street, Westminster, London, S.W.1. Organised by the Gauge and Tool Makers' Association, Standbrook House, Old Bond-street, London, W.1. Tel. HYDe Park 3451.

INTERNATIONAL RAILWAY CONGRESS. Wed., May 19, to Wed., May 26, in London. Applications to Mr. J. Dumont, International Railway Congress Association, 19 Rue du Beau Site, Brussels.

NATIONAL INSTITUTE OF AGRICULTURAL ENGINEERING, OPEN DAYS. Wed. and Thurs., May 26 and 27, at Wrest Park, Silsoe, Bedfordshire. See also page 243, *ante*.

SCOTTISH INDUSTRIAL DESIGN CONGRESS AND EXHIBITION. Wed. and Thurs., May 26 and 27, at Edinburgh. Organised by the Council of Industrial Design Scottish Committee, 95 Bothwell-street, Glasgow, C.2. Tel. Central 2991. See our issue of March 19, page 360.

CANADIAN INTERNATIONAL TRADE FAIR. Mon., May 31, to Fri., June 11, at Toronto. Apply to Miss M. A. Armstrong, Canadian Government Exhibition Commission, Canada House, Trafalgar-square, London, S.W.1. Tel. WHItehall 8701.

IRON AND STEEL INSTITUTE MEETING. Mon., June 7, to Fri., June 18, in Sweden. Apply to the Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See our issue of March 12, page 325.

FOURTH MECHANICAL HANDLING EXHIBITION. Wed., June 9, to Sat., June 19, at Olympia, London, W.14. Organised by *Mechanical Handling*, Dorset House, Stamford-street, London, S.E.1. Tel. WATerloo 3333.

CONFERENCE ON CIVIL ENGINEERING PROBLEMS IN THE COLONIES. Mon., June 14, to Fri., June 18, at the Institution of Civil Engineers, Great George-street, London, S.W.1. Apply to the secretary of the Institution at that address. Tel. WHItehall 4577. See also our issue of July 17, 1953, page 87.

SIXTH BRITISH ELECTRICAL POWER CONVENTION. Mon., June 14, to Fri., June 18, at Eastbourne. Organised by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2. Tel. TEMple Bar 9434. See also page 71 *ante*.

BUILDING PLANT EXHIBITION. Thurs., June 24, to Wed., June 30, at Hills Meadow, Reading. Organised by the Ministry of Works. Apply to the acting chief information officer, Room 117, Lambeth Bridge House, London, S.E.1. Tel. RELiance 7611.

ROYAL SHOW. Tues., July 6, to Fri., July 9, at Windsor. Organised by the Royal Agricultural Society of England, 16 Bedford-square, London, W.C.1. Tel. MUSeum 5905.

"PRODUCTION FOR PLENTY" EXHIBITION AND CONFERENCE. Wed., July 7, to Wed., July 14, at Olympia, London, W.14. Organised by the Institution of Production Engineers, 36 Portman-square, London, W.1. Tel. WELbeck 6813. See our issue of February 12, page 194.

LAUNDRY, DRY CLEANING AND ALLIED TRADES EXHIBITION. Thurs., July 8, to Sat., July 17, at Olympia, London, W.14. Organisers: F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

GREAT YORKSHIRE AGRICULTURAL SHOW. Tues., July 13, to Thurs., July 15, at Harrogate. Organised by the Yorkshire Agricultural Society, Great Yorkshire Showyard, Hookstone-drive, Harrogate. Tel. Harrogate 6014.

CONFERENCE ON DEFECTS IN CRYSTALLINE SOLIDS. Tues., July 13, to Sat., July 17, at the H. H. Wills Physical Laboratory, Royal Fort, Bristol, 8. Organised in conjunction with the Institute of Physics. Further particulars may be obtained from the secretary of the Laboratory; or the secretary, Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

RADIOISOTOPE CONFERENCE.—Mon., July 19, to Sat., July 24, at Oxford. Arranged by the Atomic Energy Research Establishment, Harwell. Further details obtainable from the conference secretary, A.E.R.E., Harwell, Didcot, Berkshire. Tel. Abingdon 620.

WORLD POWER CONFERENCE, SECTIONAL MEETING. Sun., July 25, to Tues., Aug. 10, at Rio de Janeiro, Brazil. Applications should be sent to the secretary, British National Committee, World Power Conference, 201-2 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966.

BRITISH ASSOCIATION MEETING. Wed., Sept. 1, to Wed., Sept. 8, at Oxford. Apply to the secretaries, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109.

4¼-IN. HIGH-SPEED SINGLE-SPINDLE AUTOMATIC

TURRET FORWARD AND RETURN FEEDS CONTROLLED BY RHEOSTATS

The high-speed automatic illustrated on this page is designed to facilitate rapid setting-up, it has a bar capacity of 4¼ in. and is one of three machines made by the Cleveland Automatic Machine Company, Cincinatti, U.S.A., to be added to the range of Cleveland automatics distributed in this country by the Selson Machine Tool Company, Limited, Cunard Works, Chaseroad, London, N.W.10. The most interesting feature of this machine, which is known as the 4¼ in. Dialmatic model AB, is the dial control panel from which tool feeds for all five turret stations, forward and return motion, can be independently selected. It has a single spindle and a turret feed of 8 in.

The two other machines referred to are the 2½-in. and 4¼-in. AW models, both general purpose automatics but without dial control. Their variable forward and return turret feeds are obtained through a simplified mechanical drive; otherwise they are similar to the machine described.

The main drive is provided by a four-speed motor mounted on the spindle head and driving through chain and sprocket gears. The standard change gears together with four motor speeds give 56 speeds from 21 to 648 r.p.m. To protect the machine should the drive to the spindle fail, mechanical and electrical interlocks are fitted which switch off the supply to the feed motor.

The spindle head housing the driving gears and shafts is tongued, dowelled and bolted to the bed. The driving gears have helical teeth and are made to withstand loads created by heavy cuts.

IRREGULAR STOCK HANDLED

The chucking mechanism is capable of handling slightly irregular stock and the feed shell is fitted closely so that the stock can be used to the last few inches. The chuck itself is the draw-in type and the chuck pads can be changed without removing the master chuck. A tongue on each pad fits in a groove in the master collet and prevents the pads from being jarred loose when re-stocking the machine.

The turret is cylindrical, has its axis parallel to the bed and is cast in Meehanite iron. It is mounted on a steel shaft which rests in cap bearings in the turret head; it is 14 in. in outside diameter and has a tool circle diameter of 10 in. The tool holes are 2½ in. diameter and 7 in. deep, and the tools are held by clamping bushes.

TURRET FEED CONTROL

The forward and return motions of the turret at each station are controlled by 10 rheostats and a rotary timing switch with 10 selector contacts linked to dials on the control panel. The setting of the dials determines the speed of a cam drum which is mounted on the turret shaft.

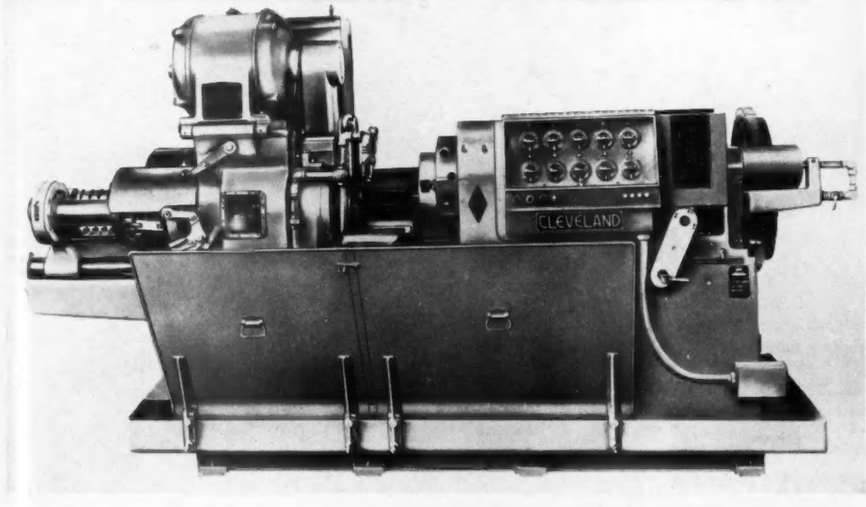
A Geneva mechanism is used for indexing, and five lateral slots cut in the periphery of the turret are engaged by a tongue which acts as a guide for the lateral movement of the turret and a stop for the location of each tool station. Coolant to the tools is fed through the turret tool holes and the flow is automatically turned off between each operation.

The rotary switches introduce the appropriate rheostat for each tool station as it comes to the working position and automatically provide the selected feed. The rate at which the tool is fed can be changed while a cut is being taken; this enables the most economical cutting speed to be determined by trial-and-error methods after the initial setting-up has been completed. When return feeds are not required the dials for each station are set in the same position for forward and return motion.

A feature contributing to the high production value of this machine is the wide tooling area on the machined surfaces of both the front and rear cross-slides, permitting the use of large forming tools or a group of simple forming tools. The wide bearing surfaces also help in eliminating vibration and assure smooth operation when heavy forming cuts are being taken. T-slots in the surfaces of both the front and back cross-slide are cut parallel to the work spindle, and micrometer dials are provided to assist in the setting-up operations.

The cross-slide and independent cut-off feeds are controlled by standard cams mounted on drums which operate directly from the main camshaft. A swivel-mounted cross-slide turning attachment permits lateral or taper turning or forming from the front of the cross-slide. The lateral feed for this attachment is taken from the turret, which engages an adjustable screw in the slide.

A separate parting-off slide is mounted on the spindle head directly above the spindle and it is independently operated from the camshaft; this slide is arranged so that it can also be used for forming operations. Another unusual feature is the motor-driven conveyor which can be fitted beneath the spindle head to remove falling swarf and chips.



The five-tool turret of this 4¼-in. automatic is controlled by rheostats, thus enabling the feed to be regulated during a cut.

* * *

A RANGE OF MANDRELS ADJUSTABLE FOR BORE SIZE

A series of six mandrels designed to accommodate components with bores of any diameter between ½ in. and 3 in. has been produced by Euco Tools, Limited, 44 London-road, Kingston, Surrey. Not only uniformly bored components but also articles with tapered bores and counterbores can be fitted on these mandrels, each of which covers a different range of bore sizes. Within the limits of a given range, components with the bore diameter at one end unequal to that at the other can also be secured.

The mandrel is supported between the centres of a lathe or grinding machine and consists primarily of a pair of hardened and ground 60-deg. cones, which are inserted in the bored ends of the component. One cone is ground integrally with a bar which forms the main part of the mandrel and the other slides on it. The sliding cone is tightened up on the workpiece by means of a nut. Spacing collars of various sizes may be fitted between the sliding cone and the nut to accommodate workpieces of various lengths.

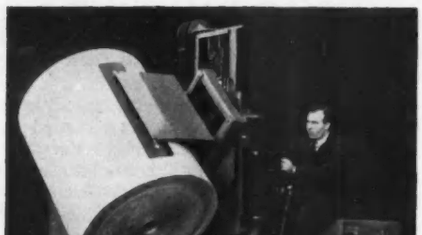
The machining lengths extend from 4 in. with the smallest mandrel to 9 in. with the largest, in steps of 1 in. The bore ranges covered by the six standard mandrels are: ½ in. to ¾ in., ¾ in. to 1 in., 1 in. to 1½ in., 1½ in. to 2 in., 2 in. to 2½ in. and 2½ in. to 3 in. Mandrels of other sizes are made specially.

* * *

INDUSTRIAL ELECTRONICS CONVENTION

The 1954 Industrial Electronics Convention, organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1, will be held at Christ Church, University of Oxford, from Thursday, July 8, to Monday, July 12, 1954, and will be devoted to the application of electronics to industrial controls, processes and computation. Among the subjects to be discussed will be industrial applications of electronic computors; electronic methods of testing, including X-rays, ultrasonics, and radioactive devices; and electronic controls, including transducers, actuators, motor controls, magnetic amplifiers and welding.

At the concluding session, on Sunday, July 11, there will be a discussion on "How Electronics Can Increase Production." Visits and demonstrations will take place on July 12.



The roll (or reel) clamping attachment fitted to this lift truck can be rotated through 90 deg. Rolls of paper, for example, can be placed vertically or horizontally.

LIFT-TRUCK ATTACHMENT FOR HANDLING ROLLS

Stacking rolls of newsprint and other materials weighing as much as 8 cwt. per roll presented a problem in mechanical handling which has now been solved by the introduction of a hydraulically-operated reel clamp. The fork-lift truck had been used for this task, but the methods employed resulted either in the added expense of palletisation or the use of two operators, one to drive the truck and another to place chocks beneath each roll as it was lowered to the floor. In the latter method, the paper was often torn.

The roll (or reel) clamp developed for this type of work is being made by Conveyancer Fork Trucks, Limited, Liverpool-road, Warrington. It has been designed for fitting to the front of their standard lift trucks. The sizes of roll that it can handle are from 24 in. to 42 in. diameter, and the weight that can be raised is slightly less than the normal lifting capacity of the truck to which it is fitted. This is due to the added weight of the clamp and the increased load centre. As the clamp both grips and rotates, the rolls may be stacked vertically or horizontally. The truck used in a recent demonstration was capable of raising two rolls simultaneously, measuring 4 ft. 6 in. long by 34 in. in diameter, and could stack three rolls on top of each other; the lift necessary to carry out this operation was 12 ft.

HYDRAULIC MECHANISM

The clamp has two arms, one fixed and the other sliding on rollers in a frame constructed from pressed-steel channel. The sliding arm is moved by twin hydraulic jacks coupled in parallel and anchored to the frame. The jacks extend to close the clamp and retract to open, so that the full piston area is used when gripping the rolls. Each arm carries a gripping plate which is pivoted on its longitudinal axis so that it can line up automatically with a roll of any diameter. Springs incorporated in the pivots ensure that the plates are always held open when offered to a roll.

The clamping mechanism is mounted on a plate that can be rotated about a spigot fitted in the centre of a fixed back-plate which is clamped to the lifting carriage. Three rollers placed on the outer edges between the front and back plates give support during rotation. Two hydraulic jacks mounted between the two plates at a tangent to the line of rotation operate in tandem to provide the turning force, each giving 45 deg. of movement when fully extended.

A separate hydraulic valve is provided for controlling each operation, in addition to the normal lift and tilt controls incorporated on the truck. The clamping control is usually mounted at the front of the truck alongside the driver and the control for obtaining rotation of the clamp is attached to one of the uprights of the frame.

To pick up a horizontal roll from the floor, the lifting mast is tilted forward and the carriage lowered so that the lower fixed arm can slip under the roll while the upper arm moves over the top to a point where it can obtain the maximum embrace. The roll can then be lifted, turned and stacked vertically. Alternatively, rolls can be taken from and placed in calendering and other machines speedily and positively, using the basic lift, tilt and turn actions.

The clamp has been designed for fitting to the standard lifting carriage and is interchangeable with other accessories. It is estimated that the time required for conversion from forks to the reel clamp is 30 min.

BRIQUETTING CAST-IRON SWARF FOR RE-MELTING

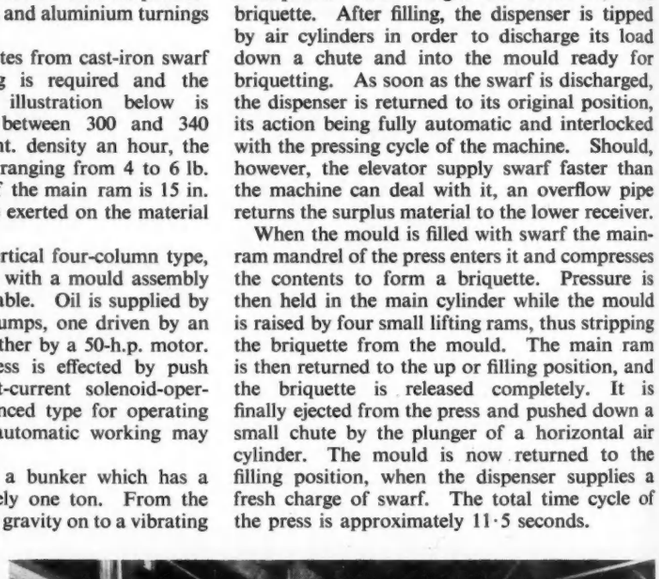
To assist in the conservation of ferrous and non-ferrous materials not readily treated by conventional baling equipment, Fielding and Platt, Limited, Gloucester, have designed and produced a 400-ton automatic hydraulic press. The machine is capable of converting cast-iron swarf into high-density briquettes, suitable for direct re-melting, at a rapid and constant rate. The makers state that it may be also used for producing briquettes from brass and aluminium turnings and drillings.

When making briquettes from cast-iron swarf no bonding or sintering is required and the press shown in the illustration below is capable of producing between 300 and 340 briquettes of 85 per cent. density an hour, the weight of the briquettes ranging from 4 to 6 lb. The length of stroke of the main ram is 15 in. and the specific pressure exerted on the material is 48 tons per sq. in.

The press is of the vertical four-column type, having fabricated tables with a mould assembly mounted on the lower table. Oil is supplied by two high-speed radial pumps, one driven by an 80-h.p. motor and the other by a 50-h.p. motor. The control of the press is effected by push buttons, through direct-current solenoid-operated valves of the balanced type for operating with oil. Completely automatic working may be arranged.

Swarf is loaded into a bunker which has a capacity of approximately one ton. From the bunker the swarf runs by gravity on to a vibrating screen which rejects large pieces of metal or other unsuitable material; these are carried away down a small side chute fitted at right angles to the direction of flow. The screened swarf passes into a receiver at the foot of an elevator which conveys it to a small hopper at the top of the press. A vibrator attached to this hopper ensures that a continuous supply of swarf enters a dispenser which weighs out swarf for one briquette. After filling, the dispenser is tipped by air cylinders in order to discharge its load down a chute and into the mould ready for briquetting. As soon as the swarf is discharged, the dispenser is returned to its original position, its action being fully automatic and interlocked with the pressing cycle of the machine. Should, however, the elevator supply swarf faster than the machine can deal with it, an overflow pipe returns the surplus material to the lower receiver.

When the mould is filled with swarf the main-ram mandrel of the press enters it and compresses the contents to form a briquette. Pressure is then held in the main cylinder while the mould is raised by four small lifting rams, thus stripping the briquette from the mould. The main ram is then returned to the up or filling position, and the briquette is released completely. It is finally ejected from the press and pushed down a small chute by the plunger of a horizontal air cylinder. The mould is now returned to the filling position, when the dispenser supplies a fresh charge of swarf. The total time cycle of the press is approximately 11·5 seconds.



Fully automatic hydraulic press which will compress cast-iron swarf into briquettes suitable for re-melting without bonding or sintering.

Labour Notes

ENGINEERING WAGES

There seems to be little hope of any immediate improvement in connection with the various important wage claims now confronting the country's national economy. Representatives of the two sides of the engineering industry met in London on March 17 to resume their negotiations on the claim of the Confederation of Shipbuilding and Engineering Unions for an overall increase of 15 per cent. in the consolidated time rates of male employees.

After careful consideration, when the claim was first presented, the employers found themselves obliged to reject the claim in full and issued a warning that any further increase in wage rates would have to be met by higher prices of the industry's products, with inevitable repercussions on exports and employment.

As a result of the reports of the courts of inquiry into the wage disputes in the engineering and shipbuilding industries, the engineering employers represented by the Engineering and Allied Employers' National Federation offered increases varying from 6*s.* to 7*s.* 4*d.* a week. These amounts were slightly in excess of the 5 per cent. increase suggested by the courts. For example, a bare 5 per cent. increase for skilled men would have meant an advance of 6*s.* 10*d.* for a week of 44 hours, compared with the 7*s.* 4*d.* for a skilled man offered by the Federation.

The employers' offer would have meant an extra 6*s.* a week for unskilled employees and 6*s.* 8*d.* a week more for the intermediate grades. These offers the trade-union leaders rejected very firmly, in spite of their having been given to understand that the employers would find it exceedingly difficult to improve upon their concession.

It seems that the men's leaders had expected an offer of something in the region of an increase of 7 per cent. and that they were disappointed in consequence. In a statement issued after the meeting, Mr. Gavin Martin, the Confederation's general secretary, suggested that if the Federation had been prepared to go beyond the "bare 5 per cent." recommended by the courts of inquiry, the unions' representatives would have been ready to bargain. Under the circumstances, they adhered to their original demand for an increase of 15 per cent., equivalent to 3*s.* in the pound.

RENEWED THREATS TO OVERTIME

A special meeting of the executive councils of the 38 unions affiliated to the Confederation was due to be held at York last Wednesday, to consider the failure of the renewed negotiations with the employers, and it was expected that there would be strong demands for the reimposition of the ban on overtime and the restriction of piecework.

It may be recalled that, following the complete rejection of the 15 per cent. demand by the employers, the unions decided to ban overtime and restrict piecework as from January 18 last. Action on that drastic scale considerably reduces pay packets and, in consequence, is often unpopular with the employees affected. The unions, not unwillingly perhaps, decided to postpone their intended embargoes when the Minister of Labour announced that he would set up courts of inquiry into the engineering and shipbuilding disputes.

At the same time, the measures were not abandoned but only postponed, pending the completion of the courts' investigations. Should the unions decide to reimpose their restrictions, there is every likelihood that they will allow an interval of several days to elapse before the embargoes become operative, in order that the Minister of Labour may have an opportunity to close the gap between the employers' offer and the Confederation's demand.

Much depends upon the attitude of the executive council of the Amalgamated Engineering Union, which was due to meet last Tuesday, in time for its decisions to be reported to the Confederation's meeting.

SHIPBUILDING WAGE OFFER REJECTED

On March 18, officials of the shipbuilding unions affiliated to the Confederation met representatives of the Shipbuilding Employers' Federation to resume negotiations on the shipbuilding-wage claim. An offer of a 5 per cent. increase, made by the Federation, was rejected with even more emphasis than had been the case with the engineering employers' offer on the previous day. Indeed, one trade-union leader dismissed the offer with the remark that it was "totally inadequate."

Almost as soon as the shipbuilding employers' proposals were made known, the unions' leaders are reported to have announced their withdrawal. They stated that the employers' offer was so disappointing to them that they were not prepared even to discuss it.

The shipbuilding and engineering claims were both presented several months ago and preliminary negotiations on them began in July last year. In addition to the large number of shipbuilding and engineering establishments affiliated to the Shipbuilding Employers' Federation and the Engineering and Allied Employers' National Federation, most of the firms outside these organisations abide by their wage decisions.

Wage increases granted to men employees are followed, almost invariably, by increases for women operatives and juveniles. Altogether, it is estimated that the wages of well over three million workpeople in the engineering, shipbuilding and ship-repairing group of industries are involved in these claims. Estimates of the cost of granting increases, based on the Confederation's full claim of 15 per cent., to this number of employees have varied between 100 and 120 million pounds a year.

ELECTRICIANS SEEK ARBITRATION

Formal notice, in accordance with the Industrial Disputes Order, that a dispute exists in the electrical-contracting industry was given by the Electrical Trades Union to the Minister of Labour on March 17.

Meetings of the National Joint Council for the Electrical Contracting Industry, which comprises representatives of the union and the employers' organisation, the National Federated Electrical Association, were held on March 12 and 15, and resulted in a deadlock. As previously reported in these columns, the union asked that a further increase should be granted by the employers in addition to the 2*d.* an hour which the Association conceded barely a fortnight ago. At the discussions by the Joint Council, the employers' side pleaded that it had not had sufficient time to consider the further claim.

In view of the deadlock at the meetings of the Joint Council, the union claimed that the industry's negotiating machinery had been exhausted and asked the Minister to arrange for an early hearing of the dispute by the Industrial Disputes Tribunal.

Mr. L. C. Penwill, the director of the Association, stated that the employers had many times advocated arbitration and that such a course had repeatedly been rejected by the union. The Association would welcome an impartial examination of the claim.

VEHICLE BUILDERS' WAGE CLAIM

The dispute which has arisen in the vehicle-building industry owing to the rejection by the employers of a wage claim for a "substantial" increase was discussed at some length at a meeting in London between conciliation officers of the Ministry of Labour and representatives of the employers' organisation on March 18.

The employers' representatives undertook to consult their constituent bodies and to inform the Minister of Labour of the result as promptly as possible. Officials of the three trade unions to which the men concerned belong gave particulars of their dispute with the employers' organisation to the Minister on March 2.

Negotiations between the two sides have been in progress since November last year, but the employers had decided that they were not able to offer any further increases in pay. About 40,000 workpeople are concerned in the claim.

COMPLAINT AGAINST A WAGE TRIBUNAL

A number of other large wage claims are also outstanding. The Association of Cinematograph Technicians, for example, have rejected as unsatisfactory an offer by the employers' organisation, the Film Laboratory Association, on the ground that it is not large enough.

At a meeting of representatives of the 18 unions affiliated to the National Federation of Building Trades Operatives on March 17, a resolution was passed expressing "profound dissatisfaction" with the employers in the industry, whose settled policy, the Federation alleged, appeared to be to force the Federation to take its wage claim to arbitration.

Another unsettled wage claim is that of the general grades in the Post Office. Their demands were remitted to an arbitration tribunal and an investigation duly took place. On March 17, Mr. C. J. Geddes, the secretary of the men's union, the Union of Post Office Workers, went to see Sir Walter Monckton concerning the union's complaint regarding the behaviour of the chairman of the tribunal dealing with the case.

During the hearing, the union's representatives walked out. It was alleged that the chairman of the tribunal had declared that the union had not established a case.

REFUSAL TO SERVICE HERMES AIRCRAFT

Intrusions of trade unions into the field of management are not new, but examples appear to be becoming more frequent. It was announced about a week ago that men employed at London Airport had decided that they would not service Hermes aircraft grounded in protective coverings outside hangars there, unless an assurance was given to them that the aircraft would not be sold for use on work that British Overseas Airways Corporation could undertake.

The men's attitude appears to have the support of the trade-union side of the local joint panel committee at the Airport, and a resolution assuring the trade-union side of their support was passed at a mass meeting of over a thousand maintenance men on March 18. The meeting asked that the Hermes should be used by the Corporation for transporting troops by air, and demanded that the whole matter should be investigated at a public inquiry.

The unions consider that many maintenance men are likely to be rendered redundant by the withdrawal of the aircraft, four of which have already been sold by the Corporation to Britavia, Limited.

NOTICES OF MEETINGS

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LONDON
"Development of Academic Libraries in British Overseas Territories," by Dr. Richard Offor. Royal Society of Arts, John Adam-street, Adelphi, W.C.2. Thurs., April 1, 6 p.m.

British Institution of Radio Engineers

LONDON
"Radio Astronomy," by R. Hanbury Brown. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Mar. 31, 6.30 p.m.
GLASGOW
Various short papers. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Thurs., April 1, 7 p.m.
LIVERPOOL
"Logic, Algebra and Relays," by Professor E. Williams. Merseyside Section. Electricity Service Centre, Whitechapel, Liverpool, 1. Thurs., April 1, 7 p.m.
MANCHESTER
Film Evening. North-Western Section. College of Technology, Sackville-street, Manchester, 1. Thurs., April 1, 7 p.m.

Chemical Society

ABERDEEN
"Some Applications of the Newer Techniques in Analytical Chemistry," by Dr. J. R. Nicholls. Robert Gordon's Technical College, Aberdeen. Thurs., April 1, 7.30 p.m.
MANCHESTER
Anniversary Meetings.
Symposium on "Dynamic Stereochemistry." Joint Meeting with the Royal Institute of Chemistry, the Society of Chemical Industry and the Institute of Petroleum. The Large Chemistry Lecture Theatre, The University, Manchester. Wed., Mar. 31, 10.30 a.m. to 6 p.m. Reception by the acting Vice Chancellor of the University. Whitworth Hall, Manchester University. Wed., Mar. 31, 8 p.m.

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ERGONOMICS RESEARCH
Conference on Human Relations in Industry

The fourth annual conference of the Ergonomics Research Society will be held at Ashorne Hill, near Leamington Spa, Warwickshire, from Monday evening, April 5, to Thursday morning, April 8, 1954. The conference will have as its theme "The Scientific Study of Human Work in Industry" and will be opened with an address by Sir George P. Barnett, H.M. Chief Inspector of Factories. At that session, the chair will be taken by Sir Frederic C. Bartlett, C.B.E., F.R.S., Emeritus Professor of Experimental Psychology at Cambridge University.

Among other subjects, papers will be contributed on physiological problems of coalmining, the study of workers in Swedish underground factories, physiological methods of measuring work, performance of workers in small-scale industries, consideration of the user in telephone research, repetitive work, and the thermal comfort of employees in light industries in summer. Dr. Leonard Carmichael, secretary of the Smithsonian Institution, Washington, will address the delegates at the closing session, on April 7.

Applications to attend the conference should be made promptly. Further information may be obtained from Mr. K. F. H. Murrell, Spinneys, Marlpit-lane, Redditch, Worcestershire.

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HARVARD FELLOWSHIPS FOR BRITISH EXECUTIVES

The Harvard Graduate School of Business Administration, in conjunction with the British Institute of Management, is offering two additional fellowships for 1954-55 to young executives in British industry. They are tenable at the School and will be valued at 2,600 dols. (about £930) per annum, of which 1,000 dols. will be for tuition and 1,600 dols. for other expenses. This sum is expected to cover the fellow's minimum outgoings, other than the cost of travel to and from the United States. Half the grant for the fellowship will be provided by Harvard School and the employers of successful candidates will be asked to provide the balance.

Fellows will receive instructon in the School's Master of Business Administration course, which is of two years' duration. They must be men of British nationality and, preferably, possess a university degree.

Official forms and further particulars may be obtained from the director, British Institute of Management, 8 Hill-street, London, W.1.

Liversidge Lecture on "Organometallic Compounds Containing Fluorocarbon Radicals," by Professor H. J. Emeléus. Large Chemistry Lecture Theatre, Manchester University. Thurs., April 1, 11.30 a.m. Reception and Anniversary Dinner. Manchester University (Staff House entrance, Burlington-street). Thurs., April 1, 7 p.m.
Annual General Meeting, at 9.45 a.m. (Open to Fellows of the Society only.) Presidential Address on "Signs of a New Pathway in Reaction Mechanism and Stereochemistry," by Professor C. K. Ingold, at 11 a.m. Large Chemistry Lecture Theatre, Manchester University. Fri., April 2.

Incorporated Plant Engineers

CARDIFF
Annual General Meeting. South Wales Branch. Grand Hotel, Westgate-street, Cardiff. Thurs., April 1, 7.30 p.m.
LEEDS
"High Frequency Heat Treatment," by Dr. K. J. Irvine. West and East Yorkshire Branch. The University, Leeds. Mon., Mar. 29, 7.30 p.m.
PETERBOROUGH
"The Place of the Modern Engineer in the Modern World," by A. L. Berridge. Eastern Gas Board's Offices, Church-street, Peterborough. Thurs., April 1, 7.30 p.m.

Institute of Fuel

CARDIFF
"Total Gasification of Coal," by Dr. F. J. Dent. South Wales Section. South Wales Institute of Engineers, Park-place, Cardiff. Fri., April 2, 6 p.m.

Institute of Marine Engineers and Institution of Naval Architects

SOUTHAMPTON
"The Survey of Wood Craft," by J. M. Robertson. Annual General Meeting. Southern Joint Branch. Technical College, St. Mary-street, Southampton. Tues., Mar. 30, 7 p.m.

Institute of Metals

LONDON
Annual General Meeting. Symposium on "Brittle Fracture of Metals." (i) "Molybdenum," by Dr. L. Northcott; (ii) "Manganese and Chromium," by Dr. A. H. Sully; and (iii) "Theoretical Aspects," by Dr. A. A. Wells. London Local Section. Thurs., April 1, 6 p.m.
OXFORD
Annual General Meeting. Oxford Local Section. Cadena Café, Cornmarket-street, Oxford. Tues., Mar. 30, 7 p.m.

Institute of Road Transport Engineers

BIRMINGHAM
Annual General Meeting. Midlands Centre. Crown Inn, Broad-street, Birmingham. Sat., April 3, 7.30 p.m.
BRISTOL
Annual General Meeting. Western Centre. Grand Hotel, Bristol. Thurs., April 1, 7.30 p.m.
CARDIFF
Annual General Meeting. South Wales Group. South Wales Institute of Engineers, Park-place, Cardiff. Fri., April 2, 7 p.m.
LEEDS
Annual General Meeting. Yorkshire Centre. Hotel Metropole, King-street, Leeds, 1. Thurs., April 1, 7.30 p.m.

Institute of Welding

LONDON
Annual General Meeting. North London Branch. The Polytechnic, Regent-street, W.1. Thurs., April 1, 7.30 p.m.
CHATHAM
Annual General Meeting and Film Evening. Medway Section. Sun Hotel, Chatham. Thurs., April 1, 7.15 p.m.

Institution of Civil Engineers

LONDON
"Construction of a New Runway at Amman, Jordan," by Group-Capt. A. R. Macrae and Sqd.-Ldr. A. F. Smith. Airport Engineering Division. Tues., Mar. 30, 5.30 p.m.

Institution of Electrical Engineers

LONDON
"Possibilities of a Cross-Channel Power Link," by D. P. Sayers, M. E. Laborde and F. J. Lane. Thurs., April 1, 5.30 p.m.
BIRMINGHAM
"Development and Application of Nuclear Reactors," by R. V. Moore. South Midland Centre. James Watt Memorial Institute, Birmingham. Mon., Mar. 29, 6 p.m.
CAMBRIDGE
"Earthing," by P. W. Cave. East Midland Centre. University Arms Hotel, Cambridge. Tues., Mar. 30, 7 p.m.
HULL
"Voltage Transformers and Current Transformers Associated with Switchgear," by W. Gray and A. Wright. North Midland Centre. Yorkshire Electricity Board's Offices, Ferensway, Hull. Thurs., April 1, 7.15 p.m.
LOUGHBOROUGH
"Some Problems of a Plant Engineer in Nuclear Chemical Division," by W. E. Harris. East Midland Centre. Loughborough College, Loughborough. Tues., Mar. 30, 6.30 p.m.
MANCHESTER
"The Kemano Hydro-Electric Development and Associated Kitimat Aluminium-Reduction Works," by F. L. Lawton. North-Western Centre. Engineers' Club, Manchester. Mon., Mar. 29, 6.15 p.m.
NEWCASTLE-UPON-TYNE
Informal Meeting. North-Eastern Centre. Liberal Club, Newcastle-upon-Tyne. Fri., April 2, 7 p.m.
YORK
"Design Features of Certain British Power Stations," by S. D. Whetman and A. E. Powell. North Midland Centre. Royal Station Hotel, York. Tues., Mar. 30, 7 p.m.

Institution of Engineering Inspection

GLASGOW
Informal Lecture by G. Miles. West of Scotland Branch. St. Enoch Hotel, Glasgow. Wed., Mar. 31, 7.30 p.m.

Institution of Mechanical Engineers

LONDON
Discussion on "The Future of High-Compression Petrol Engines versus Diesel Engines for Passenger Cars." Automobile Division. Tues., Mar. 30, 6.45 p.m.
"Shrink Fit Investigations on Simple Rings and on Full-Scale Crankshaft Webs," by Professor A. S. T. Thompson, Professor A. W. Scott and Dr. C. M. Moir. Applied Mechanics Group. Fri., April 2, 5.30 p.m.
BRISTOL
"Aeronautical and Mechanical Engineering, 1929 to 1954: A Retrospect and Prospect," by Wing-Cmdr. T. R. Cave-Brown-Cave. Western Branch. Royal Fort, Bristol. Wed., Mar. 31, 6.30 p.m.

Institution of Production Engineers

LUTON
"Uses of Liquid Air," by A. H. Cockett. Town Hall, Luton. Tues., Mar. 30, 7.15 p.m.
READING
"Some Wider Aspects of Management," by Sir Ewart Smith. Great Western Hotel, Reading. Thurs., April 1, 7.30 p.m.

Institution of Structural Engineers

SWANSEA
"Recent Developments in Timber Structures," by S. Woolf. Wales and Monmouthshire Branch. Mackworth Hotel, Swansea. Wed., Mar. 31, 6.30 p.m.

Institution of Works Managers

NOTTINGHAM
Annual General Meeting. Notts and Derby Branch. Welbeck Hotel, Nottingham. Fri., April 2, 8 p.m.

Iron and Steel Institute

LONDON
"The Ugine-Sejournet Process for the Hot Extrusion of Steel," by J. Sejournet. Joint Meeting with the Société des Ingénieurs Civils de France (British Section). Thurs., April 1, 6 p.m.

Junior Institution of Engineers

LONDON
"Some Impressions of North America," by J. Foster Petree. Townsend House, Greycoat-place, S.W.1. Fri., April 2, 7 p.m.

Leeds Metallurgical Society

LEEDS
"Bearings and Bearing Alloys," by R. T. Rolfe. Chemistry Department, The University, Leeds, 2. Thurs., April 1, 7.15 p.m.

Royal Aeronautical Society

LONDON
"Inter-Action Between Shock Waves and Boundary Layers and Its Importance in High-Speed Flight," by Dr. D. W. Holder. Tues., Mar. 30, 7 p.m.

Sheffield Metallurgical Association

SHEFFIELD
"Brittle Fracture," by T. S. Robertson. B.I.S.R.A. Laboratories, Hoyle-street, Sheffield, 3. Tues., Mar. 30, 7 p.m.

Société des Ingénieurs Civils de France (British Section)

LONDON
"The Ugine-Sejournet Process for the Hot Extrusion of Steel," by J. Sejournet. Joint Meeting with the Iron and Steel Institute, 4 Grosvenor-gardens, S.W.1. Thurs., April 1, 6 p.m.

Society of Industrial Engineers

GLASGOW
"Rate Fixing," by S. K. Bhattacharyya. The Building Centre, 425 Sauchiehall-street, Glasgow. Sat., April 3, 10 a.m.

Society of Instrument Technology

LONDON
"Automatic Control in the Iron and Steel Industry," by S. S. Carlisle. Manson House, Portland-place, London, W.1. Tues., Mar. 30, 7 p.m.

West of Scotland Iron and Steel Institute

GLASGOW
"Engineering Problems Connected with the Installation and Commissioning of a Cross-Country Mill," by Dr. W. S. Walker. Joint Meeting with the Iron and Steel Engineers Group, Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Mar. 31, 6.45 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Aslib, 4 Palace-gate, London, W.8. (WEStern 6321.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Chemical Society, Burlington House, Piccadilly, London, W.1. (REGent 0675.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Fuel, 18 Devonshire-street, London, W.1. (LANgham 7124.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institute of Welding, 2 Buckingham Palace-gardens, London, S.W.1. (SLOane 9851.)
Institution of Civil Engineers, Great George-street, London, S.W.1. (WHItehall 4577.)
Institution of Electrical Engineers, Savoy-place, Victoria-embankment, London, W.C.2. (TEMple Bar 7676.)
Institution of Engineering Inspection, 28 Victoria-street, London, S.W.1. (ABBey 3794.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Naval Architects, 10 Upper Belgrave-street, London, S.W.1. (SLOane 4622.)
Institution of Production Engineers, 36 Portman-square, London, W.1. (WELbeck 6813.)
Institution of Structural Engineers, 11 Upper Belgrave-street, London, S.W.1. (SLOane 7128.)
Institution of Works Managers, 67-68 Chandos-place, London, W.C.2. (TEMple Bar 8324.)
Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. (SLOane 0061.)
Junior Institution of Engineers, 39 Victoria-street, London, S.W.1. (ABBey 6968.)
Leeds Metallurgical Society, Department of Metallurgy, The University, Leeds, 2.
Royal Aeronautical Society, 4 Hamilton-place, London, W.1. (GROsvenor 3515.)
Sheffield Metallurgical Association, 15 Crescent-road, Sheffield, 7. (Sheffield 53674.)
Société des Ingénieurs Civils de France (British Section), 82 Victoria-street, London, S.W.1. (VICtoria 6838.)
Society of Industrial Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6511.)
Society of Instrument Technology, 55 Tudor-gardens, London, W.3.
West of Scotland Iron and Steel Institute, 39 Elmbank-crescent, Glasgow, C.2. (Central 5181.)